POWER

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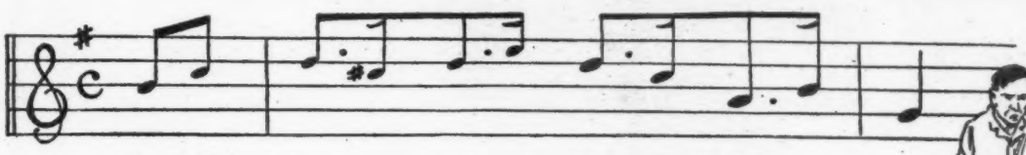


The Old Story

By R. T. Strohm

The distance from the fuel to the bottom boiler plate
Isn't over twenty inches, I can swear,
And often, when the coal gets piled up thickly on the grate,
There is something less than half of that to spare.
The fuel's soft and gassy, and the vapors that distill
Fill the furnace with a long and snaky flame,
But long before the gases burn, they get a sudden chill—
And the smoke goes up the chimney just the same.

The stoker is so busy with attending to the fires
That he has no leisure time in which to learn;
But somewhere he's discovered that a gassy coal requires
Quite a large supply of air to make it burn.
And so he grabs the ashpit doors and sets them open wide,
And he swings the damper level in its frame;
He gazes on his handiwork and feels a thrill of pride—
And the smoke goes up the chimney just the same.

He seems to think that every lump of coal should be aglow
With a color from a yellow to a red,
So every other minute he gets busy with the hoe
And proceeds to rake and mix the fuel bed.
Combustion is a principle of which he's never heard,
While efficiency to him is but a name;
And as for CO_2—he doesn't understand the word—
And the smoke goes up the chimney just the same.

He doesn't have a scrap of information on the rate
Of evaporation based upon the coal;
And if you chanced to ask him, I am sure he couldn't state
What the power cost, to save his very soul.
His ignorance is deep and dense, and pitiful to see,
Yet I hesitate to censure or to blame.
His boss appears to think it well, and so, why shouldn't he?—
And the smoke goes up the chimney just the same.

Selling Current on a Small Margin

By Thomas Wilson

SYNOPSIS—A small water and steam plant selling its output for an average of 3.28c. per kw.-hr. The average operating cost is 0.87c. per kw.-hr. and the total cost per unit, including overhead, office and line expenses, is 2.88c.

In Goshen, Ind., the Hawks Electric Co. has an interesting combination water and steam plant which is supplying current for light and power to the city and seven surrounding villages, within a radius of 18 miles. Rural service is also being developed and in time will add materially to the load. A flat rate of 6c. per kw.-hr. is charged for lighting in the residence district and in the business center the charge per unit is 5c. Power rates are graduated from 4 to 1c. per kw.-hr., depending upon the amount of current used and the hours of service. The average return for the current sold is 3.28c. per kw.-hr. For an 800-kw. plant this charge is low and it is maintained at a profit only by careful and efficient management.

During the year ending June 30, 1914, the total connected load was 2432 kw. Of this the lighting amounted to 1025 kw. and the balance of 1407 kw. was power load. The actual output of the station was 1,842,507 kw.-hr., the power load being slightly in excess of the lighting. To supply this service there is capacity to generate 300 kw. by water and 500 kw. by steam. Although of larger capacity, the steam plant is the auxiliary. As long as water is available the hydraulic plant

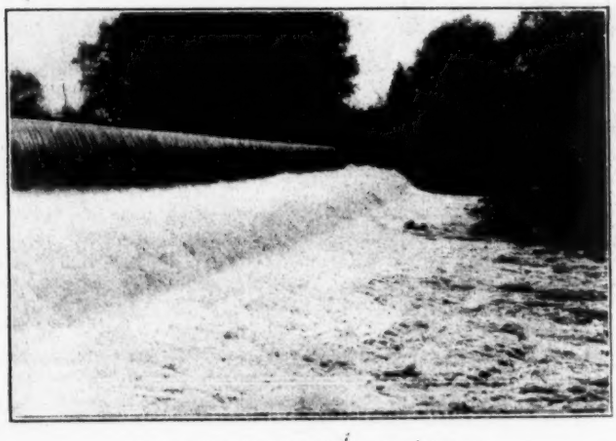


FIG. 1. DAM ON ELKHART RIVER

is used, although from 6 a.m. to 10 p.m., with the exception of Sundays and holidays, the steam plant is kept in operation the year around. When water is plentiful the steam equipment is merely floating on the line the greater part of the day, and at the peak it pulls up to 50 per cent. of rating for an hour. During the dry season the entire load is shifted to the steam plant so that it may operate at the most economical point. By careful manipulation and shifting of the load between the two plants the cost of production is held to a minimum. "Service first and then economy," is the company's slogan, and this is why the steam plant is kept ready to take the load at a moment's notice.

Back in 1866 the water power was first developed, the dam being located two miles above the city on the Elkhart River. The length of the spillway is 175 ft., and the storage reservoir above the dam covers 150 acres. The average flow of the river is 835 sec.-ft., which, with the effective head of 16 ft. now available, will develop, at 85 per cent. efficiency, about 1200 hp. In those days the development furnished mechanical energy to a number of factories. At the point of delivery the headrace was covered over and the quantity of water limited to the requirements of the initial installation. Two 300-hp. vertical water-wheels were installed. These are still retained and the power developed is utilized to drive a flour mill.

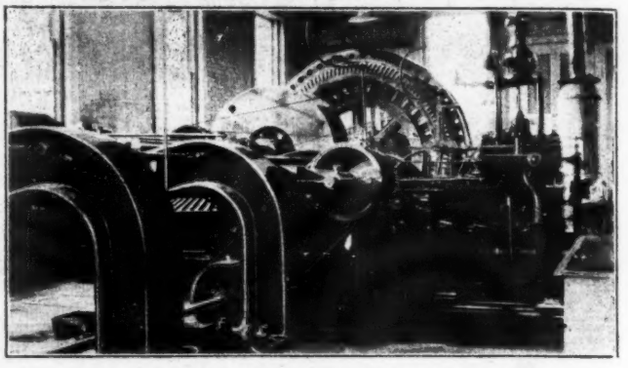


FIG. 2. HYDRAULIC GENERATING PLANT

In 1898 the old water-power plant and an independent electric plant were purchased by the present company. The steam plant, as remodeled, consisted of a cross-compound Corliss engine driving a 300-kw. generator through a lineshaft to which were also coupled the two 300-hp. waterwheels. Under the new management the generating and service equipment was standardized for three-phase, 60-cycle, 2200-volt current, and the old 140-cycle single-phase service eliminated. The load continued to grow and in 1907 additional power was required. As the headrace was covered and the supply of water limited, a new water plant was erected a short distance away. The equipment consisted of a 300-kw. generator geared to two 300-hp., 50-in. vertical waterwheels. Either wheel, or both if desired, may be used to drive the generator. Even with the new plant there was a decided shortage of power during the dry months, and shortly after, a new steam plant was installed in a separate building, the generating equipment consisting of a 500-kw. turbo-generator. The waterwheels are controlled by an oil-pressure governor, and the two plants are operated in parallel or individually, depending on load requirements. This has proved to be a very flexible arrangement, for when the load is comparatively light one waterwheel is kept in service, and when it increases the second is cut in, and then the steam turbine when the load exceeds the capacity of the generator driven by the waterwheels. To guard against a possible interruption of service the steam turbine is operated daily from 5 a.m. to 10 p.m. and the boilers are banked the remainder of the day. In the dry season there is little water and the entire electrical load is handled by the steam plant.

The old turbines are still retained, and the power they develop is leased to a flour mill. The generator is used as a synchronous motor. It is given a small mechanical load and over-excited to raise the power factor on the two generating stations. With this exception the old equipment has nothing to do with the new plants and in the discussion following will not be considered.

Steam-Power Plant

As previously stated, this consists of one generating unit. The turbine is of the reaction type taking steam at 175 lb. pressure and no superheat. The generator is a standard three-phase, 60-cycle machine, running at 3600 r.p.m., and delivering current at 2200 volts to conform with the water-power plant. The surface condenser, has 1560 sq.ft. of cooling surface, which reduces to 3 sq.ft. per kilowatt of generator rating. This is more than is generally used, but was provided in this case, because the circulating water flows through the condenser by gravity. It is taken from the headrace and discharged to the tailrace. The condenser is not much lower than the water level in the former, so that the head is low and the quantity of water flowing through it comparatively small. Owing to the above arrangement there is no need for a circulating pump. The wet-air pump is steam-driven, with a tail-pump attached to deliver condensate to the heater. The latter is of the open type and is supplied with exhaust steam from the air pump, boiler-feed pumps and an engine-driven exciter unit. There is also a motor-driven exciter, each being rated at 10 kw.

To supply steam to the turbine there are two 300-hp. vertical water-tube boilers with dutch-oven furnaces and rocking grates. The latter have 18 sq.ft. of surface each and compared with the heating surface in the boilers the ratio is 1 to 62. The grate surface is a trifle less than that usually provided, but a good grade of coal is burned and there is no occasion to force the boilers over their rated capacity. The operating pressure is 175 lb. and no superheating surface has been installed. Feed-water is supplied from the heater by either one of two duplex pumps, and before it enters the boilers it is measured by a flow-meter. The furnaces operate under natural draft supplied by a radial brick stack 125 ft. high and 5 ft. in diameter.

Coal is received in hopper-bottom railway cars from which it is dumped into a track hopper. It is elevated and carried to the bunkers in front of the boilers by an overhead I-beam trolley equipped with an electric hoist. While in the bucket the coal is weighed by a track scale. Owing to the varying load on the steam plant the coal is hand-fired to the furnaces. Ashes are handled by the same hoist. A turntable and an extension of the track at right angles to the main line make it possible to drop the bucket in front of the ashpits.

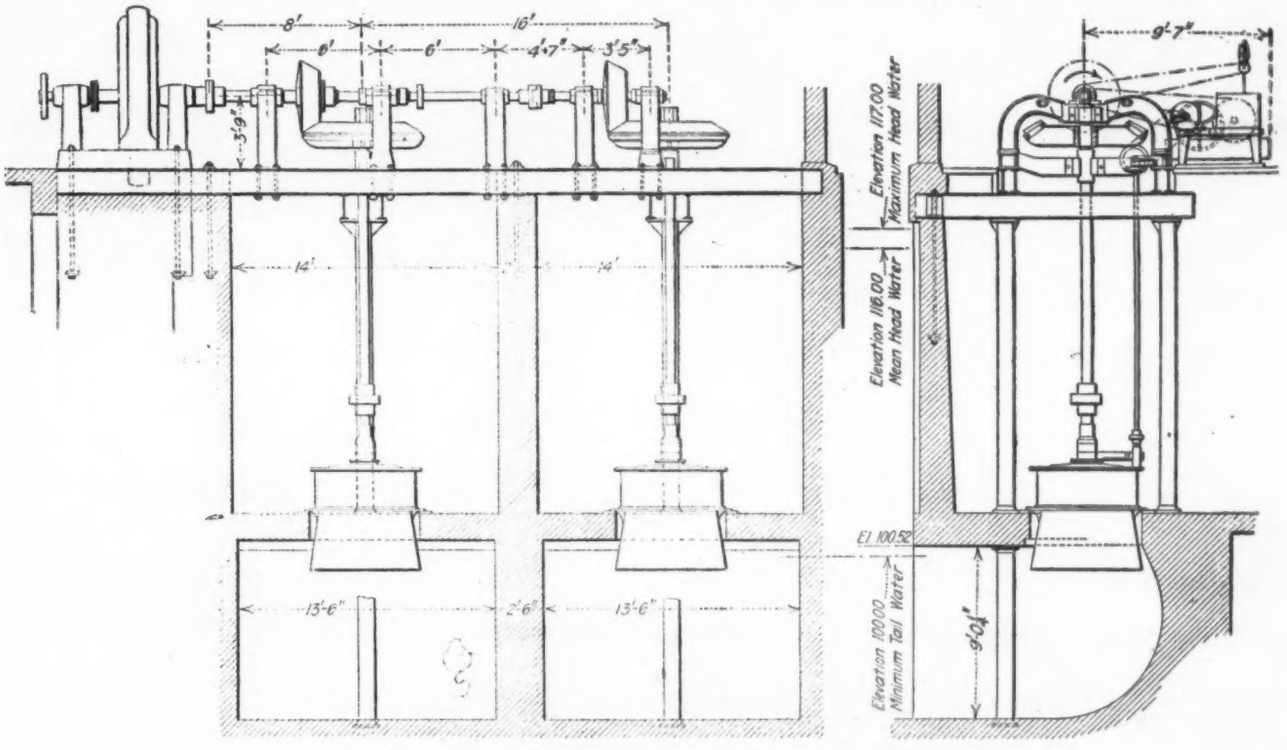


FIG. 3. SECTIONAL ELEVATION THROUGH WATER-POWER PLANT

Operating Data and Cost of Equipment

As shown in Table 1, West Virginia bituminous coal is burned. This fuel runs about 13,000 B.t.u. per lb., and the average cost per ton of 2000 lb. delivered is $2.94. During the year ending June 30, 1914, over five million pounds of coal was burned. Per kilowatt-hour at the switchboard the average was 6 lb. This amount of coal generated steam for the turbine, the auxiliaries and the boiler-feed pumps, and included the coal re-

TABLE 1 STEAM-POWER GENERATION

Kilowatt-hours generated by steam power	904,307
Kind of coal used	Ohio & W. Va. bituminous
Average cost per ton of 2000 lb. delivered	$2.94
Pounds of coal consumed	5,469,308
Pounds of coal per kw.-hr. at switchboard	6
B.t.u. consumed per kw.-hr. at switchboard	72,000
Pounds of water evaporated per kw.-hr. at switchboard	37
Pounds of water evaporated per lb. of coal	5.8

quired for banking from 10 p.m. to 6 a.m., when the turbine was not in operation. Since the turbine is operating at a light load much of the time, high economy cannot be attained. For all purposes 37 lb. of water was evaporated per kilowatt-hour at the switchboard and per pound of coal 5.8 lb. of water was turned into steam.

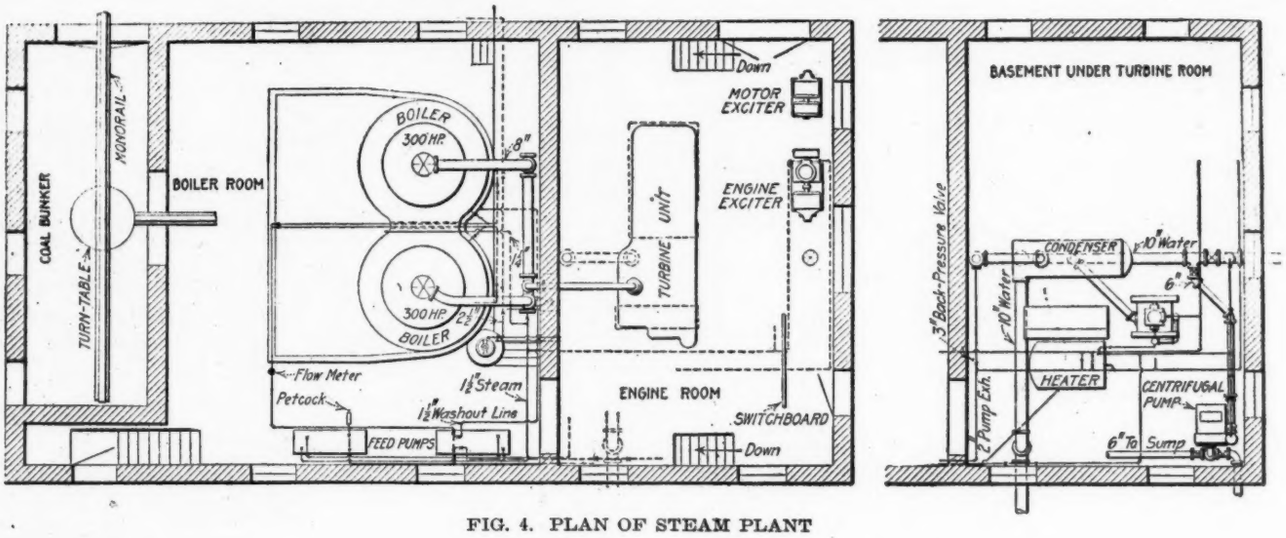


FIG. 4. PLAN OF STEAM PLANT

Table 2 gives the cost of the steam and water plants. Including the land, a substantial brick building and all equipment, the total cost of the steam plant was $38,925;

TABLE 2. COST OF POWER PLANTS

Steam:		Water:	
Land	$1,000	Land	$7,000
Building	9,527	Building	11,557
Generating equipment	18,024	Hydraulic generating plant	13,688
Boiler plant	10,374	Hydraulic power works	47,178
	$38,925		$79,423
Generating capacity, kw	500	Generating capacity, kw	300
Cost per kw	$77.85	Power capacity, equiv. kw	450
		Cost per kw	$105.90

this reduces to $77.85 per kilowatt of generating capacity. The total cost of the water-power development, including the old and the new plants, amounted to $79,423, or $105.90 per kw. when the two waterwheels supplying power directly to the flour mill are given an equivalent kilowatt rating of 450. Considering only the generating plant, the unit cost would be higher and would naturally depend on how the cost of the dam, headrace, etc., was proportioned between the two water-power plants.

Table 3 shows the monthly output of the two stations. The total for the year is 1,842,507 kw.-hr. As determined at the foot of the table, the maximum demand factor was 81 per cent. and the load factor of the two plants 32 per cent.

TABLE 3. MONTHLY RECORD OF STATION OUTPUT IN KILOWATT HOURS

July, 1913	140,125	February, 1914	142,705
August, 1913	143,650	March, 1914	154,035
September, 1913	147,440	April, 1914	155,605
October, 1913	149,500	May, 1914	153,421
November, 1913	154,790	June, 1914	149,321
December, 1913	179,440		
January, 1914	172,475	Total	1,842,507

$$\text{Max. demand factor} = \frac{\text{max. load on station for 15 min.}}{\text{max. available capacity of station}} = \frac{650}{800} = 81 \text{ per cent.}$$

$$\text{Load factor} = \frac{\text{kw. generated during year}}{\text{max. load in kw. for 15 min.} \times \text{av. hr. service per day} \times 365}$$

$$= \frac{1,842,507}{650 \times 24 \times 365} = 32 \text{ per cent.}$$

Operating expenses are summarized in Table 4. The items enumerated total $13,100.77 and per kilowatt-hour generated reduce to 1.45c. By water 938,200 kw.-hr. was generated at an average cost of 0.32c. per unit at the switchboard. The average cost for the total current generated is 0.8731c. per kw.-hr. Overhead expenses on the steam plant and on the generating end of the water-power plant increase the cost per unit to 1.3c. When distribution, metering, office and all other expenses are included, the total cost per unit is 2.88c.

An interesting comparison of the relative cost of generating current by water and by steam is given in Table 5. Incidentally, these data also show how the cost per unit varies with the output. When generating 304,862 kw.-hr. in the steam plant, during the first half of 1914, the cost per kilowatt-hour reached 2.04c. In the pre-

TABLE 4. OPERATING EXPENSE, YEAR ENDED JUNE 30, 1914

Steam Power	
Labor	$4001.05
Coal	8063.50
Miscellaneous supplies	436.99
Maintenance of equipment	447.82
Maintenance of building and grounds	151.41
Total	$13100.77
Kilowatt-hours generated by steam power	904,307
Cost per kilowatt-hour generated	1.45c.
Hydraulic Power	
Labor	$2045.63
Miscellaneous supplies	117.55
Maintenance of hydraulic works	685.72
Maintenance of power plant	125.15
Maintenance of building and grounds	13.02
Total	$2987.07
Kilowatt-hours generated by water power	938,200
Cost per kilowatt-hour generated	0.32
Summary of Costs	
Average power cost per kilowatt-hour at switchboard	0.8731c.
Depreciation on generating plants, 5 per cent	0.1930
Interest on investment and taxes, 6 per cent	0.2320
Distribution, metering, office, etc	1.5819
Total	2.8800c.

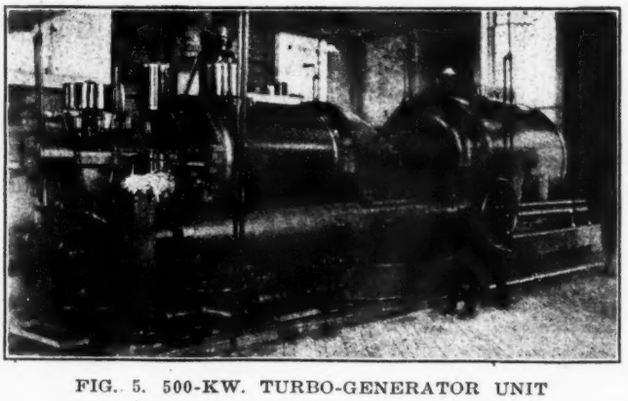


FIG. 5. 500-KW. TURBO-GENERATOR UNIT

vious half-year it had averaged 1.14c., but the load was practically double. In the latter half of 1914 the load ran up to 863,816 kw.-hr. and the cost per unit dropped to 0.94c. For the six-month periods given in the table

TABLE 5. UNIT COST AT SWITCHBOARD

	Operating	Fuel	Total	Kw.-hr.	Unit Cost
		Steam			
Last half 1913....	$2221.36	$4626.95	$6848.31	599,445	$0.0114
First half 1914...	2785.14	3436.55	6221.75	304,862	0.0204
Last half 1914...	2769.40	5364.83	8134.23	863,816	0.0094
		Water			
Last half 1913...	.....	.....	$1483.20	315,500	$0.0047
First half 1914...	.....	.....	1503.87	622,700	0.0024
Last half 1914...	.....	.....	1686.57	181,600	0.0093
		Combined			
Last half 1913...	.....	.....	$8331.51	915,000	$0.0091
First half 1914...	.....	.....	7725.62	928,500	0.0083
Last half 1914...	.....	.....	9820.80	1,045,100	0.0094

the combined or average costs for the entire output were maintained nearly constant, the average per unit being 0.87c. Considering the conditions under which the plant operates, this is an exceptionally good figure which will become better as the load increases.

To Owen C. Cover, general manager of the company, we are indebted for much of the information contained in this article.

PRINCIPAL EQUIPMENT OF HAWKS ELECTRIC CO. PLANT

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
2	Water wheels	Vertical	50-in., 300 hp.	Drive generating unit	Normal head 16 ft.	James Leffel & Co.
1	Governor	Oil-pressure	.....	Control water wheels	.....	Woodward Governor Co.
1	Generator	Alternating-current	300-kw.	Main generating unit	Three-phase, 60-cycle, 2200-volt	Allis-Chalmers Co.
1	Turbine	Reaction	500-kw.	Main generating unit	175 lb. steam, no superheat, 3600 r.p.m.	Allis Chalmers Co.
1	Generator	Alternating-current	500-kw.	Main generating unit	Three-phase, 60-cycle, 2200-volt	Allis Chalmers Co.
1	Condenser	Surface	1560-sq.ft.	Serves turbine	.....	Wheeler Condenser & Engineering Co.
1	Pump	Edwards wet-air	7x16x10-in.	Serves condenser	Steam, 175 lb.	Wheeler Condenser & Engineering Co.
1	Pump	Power	3x6-in.	Condensate to heater	Attached to air pump	Wheeler Condenser & Engineering Co.
2	Exciters	Direct-current	10-kw.	Excite main generator	One driven by 6x6-in. A.B.C. vertical engine; one driven by 5-hp. induction motor	Allis-Chalmers Co.
2	Boilers	Vertical water-tube	300-hp.	Steam generators	175-lb. operating pressure, natural draft	Bass Foundry & Machine Co.
2	Grates	Rocking	40-sq.ft.	Serve boilers	.....	Kelly Foundry & Machine Co.
1	Chimney	Radial brick	125 ft. high, 5 ft. diam.	Draft for boilers	.....	Custodis, Alphons Chimney Construction Co.
1	Hoist	Monorail	1-ton	Coal and ashes	.....	Brown Hoisting Machinery Co.
1	Scale	Track	.....	Weigh coal	.....	Fairbanks, Morse & Co.
1	Heater	Open	600-hp.	Heat boiler-feed water	Exhaust steam from auxiliaries	Hoppers Manufacturing Co.
2	Pumps	Duplex	4½x7½x10-in.	Boiler feed	175-lb. steam	Henry R. Worthington
1	Meter	Flow	.....	Measure water to boilers	.....	General Electric Co.

Power from Peat in Canada

The Dominion Government through the Mines Department has been investigating the potential energy of peat. Dr. Haanell, the director, shows that with peat at $1.50 per ton, 25 per cent. moisture, delivered at the producer plant, and having a nitrogen content of 1.5 to 2 per cent., power can be produced as cheaply as with many hydro-electric plants; and that where only gas is generated the revenue derived from the sale of the ammonia sulphate produced is sufficient to pay a profit on investment and to deliver the gas free of charge.

There are bog areas in Canada of large extent, well suited for the manufacture of peat for fuel and the production of power. A commission was sent by the Canadian Government to Europe to investigate, chiefly in Germany, and report upon the methods and practices there employed for generating power from peat. Especial attention was paid to the byproducts and to the methods of preparing the peat for gas producers or steam boilers.

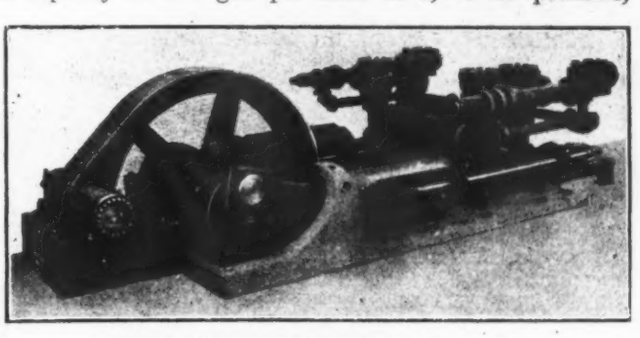
Much of the peat in Canada has a high nitrogen content, and this element can be profitably recovered in the ammonia gas formed in the byproduct recovery producer. The ammonia gas is fixed by sulphuric acid and the resulting product—ammonium sulphate—is then sold for agricultural purposes, for which the demand is considerably greater than the supply at prices ranging from $65 to $70 per ton.

Thirteen bogs examined scientifically and thoroughly in Ontario are estimated to have a total fuel value of 43,000,000 tons, 25 per cent. moisture. From these could be produced a quantity of power gas sufficient to generate 40,000 hp. continuously for 100 years.

The quantity of gas in a ton of this peat is 90,000 cu.ft., and the amount available for power would be 67,000 cu.ft. There are several peat plants in operation for the recovery of ammonium sulphate alone; with the production of power gas in addition, the possibilities are great. The sale of ammonium serves to reduce the cost of generating gas and power. The main object desired is to establish a plant for the production of gas to be used for power and other purposes. If the energy developed at a hydro-electric plant must be transmitted long distances its cost to the user would be greater than a gas producer plant nearer home. In such case the hydro-electric plant may fail and the fuel power plant succeed. A market must, therefore, be established for the power it is proposed to generate before actual building of a by-product recovery power gas plant is undertaken; otherwise it might not be a success commercially.

Deane High-Pressure Pump

The Deane Steam Pump Co., Holyoke, Mass., has recently constructed a number of high-pressure hydraulic pumps, along the lines of the one illustrated. This has a capacity of 500 gal. per min. at 1,500 lb. pressure,



HIGH-PRESSURE HYDRAULIC PUMP

requiring a 500-hp. motor for its operation. The drive is through a single reduction of double-helical or herring-bone gears and a flexible coupling, the motor operating at 600 r.p.m.

The high-speed pinion shaft bearings are of the multiple-ring oiler type. The crankshaft bearings are of the quarter-box type, with wedges on both sides so that the gear centers may be maintained. The crank disks are steel castings and the pins are cast integral with the

disks. Both inside and outside crossheads are of steel castings, the inside one being fitted with adjustable shoes running in a bored guide. The crosshead shoes are adjustable from the front, or the connecting-rod end of the crosshead. The girders underneath the pinion-shaft bearings are cast integral with the pedestal bearings to insure maximum rigidity and permanent alignment of the parts.

Coal Breaker and Scraper

By J. P. Considine

SYNOPSIS—An ingenious machine designed to break up coal frozen in railway cars and scrape it into the track hopper.

Views of a machine designed for breaking up frozen heavy materials in cars and for scraping them out of the cars are shown in Figs. 1 and 2. The Edison Illuminating Co., of Detroit, has for many years experienced considerable difficulty in unloading a sufficient amount of coal to meet the load demand at its power houses during the winter season when the coal had become frozen in the cars. To overcome this difficulty a machine was designed especially to facilitate the work.

As received by this company during the winter season, the coal is frozen at the top and bottom of the car for a distance of about two feet, and often throughout the entire depth of the car. In either case the coal would not flow from the car when the doors were opened and it would be necessary to force an opening by driving a small pipe with a hand hammer through the frozen coal at several places. This operation required from 30 to 90 min. After an opening had been made the coal was loosened by picks. The whole work of unloading a car would require from 1½ to 4 hr., depending upon the degree to which the contents were frozen.

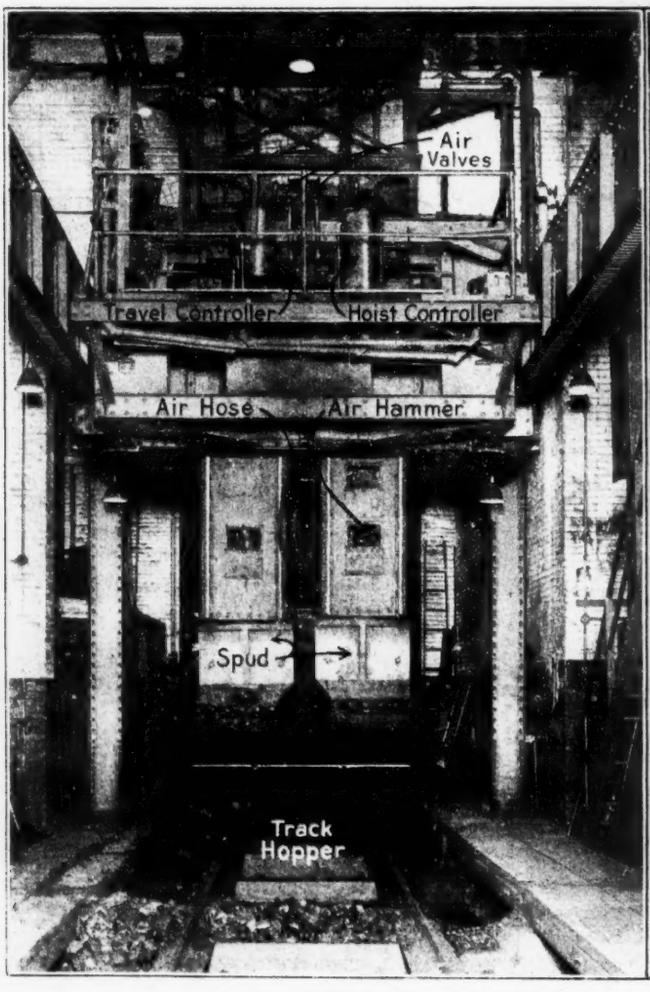


FIG. 1. FRONT VIEW OF BREAKING AND SCRAPING MACHINE

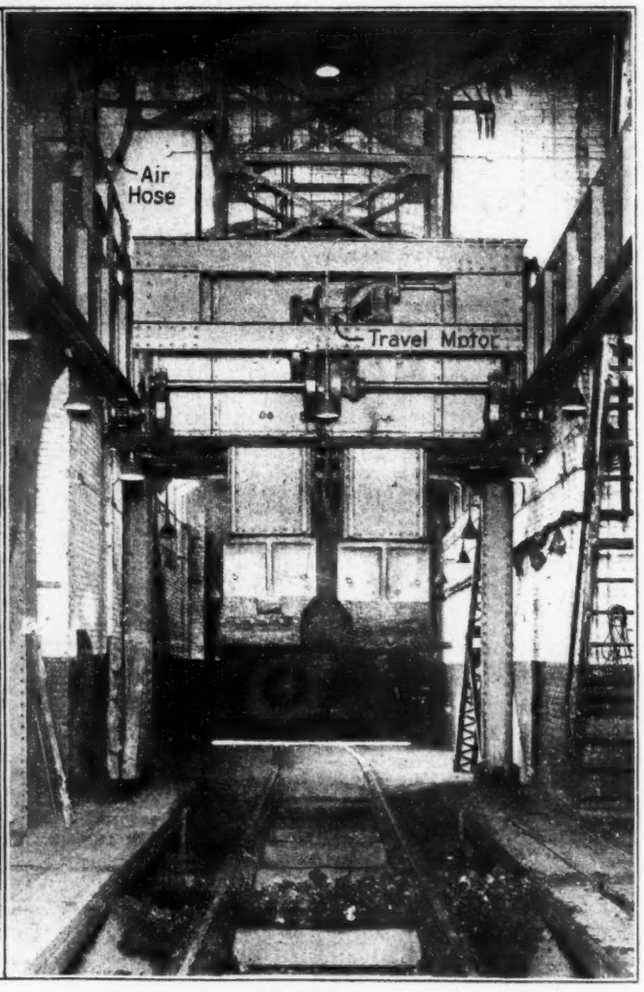


FIG. 2. REAR VIEW SHOWING TRAVEL MOTOR AND GEARED RACKS

The coal breaker and scraper consists of a carriage supported by, and traveling longitudinally on, a girder runway, and two spuds with air hammers carried by the carriage. The carriage, weighing 15 tons, is held in position by four double-flanged wheels which run on the top of the runway girders, and is driven by a 22-hp.

variable-speed motor through pinions that mesh into racks fastened to the bottom of the girders. This arrangement affords a positive drive that does not depend upon the tractive effort of the flanged wheels. The travel motor is provided with a solenoid brake for promptly arresting the high-speed parts of the mechanism when the current is shut off. A limit device is also provided for the travel mechanism, to prevent running off the ends of the racks. The carriage carries two spuds, each weighing 4½ tons and each hung by a cable.

In the spud above the anvil block there is a double-acting air hammer weighing 3,400 lb. to which is connected a flexible air hose. The two spuds occupy approximately the full width of the car. One or both may be operated at a time, being raised by one 52-hp.

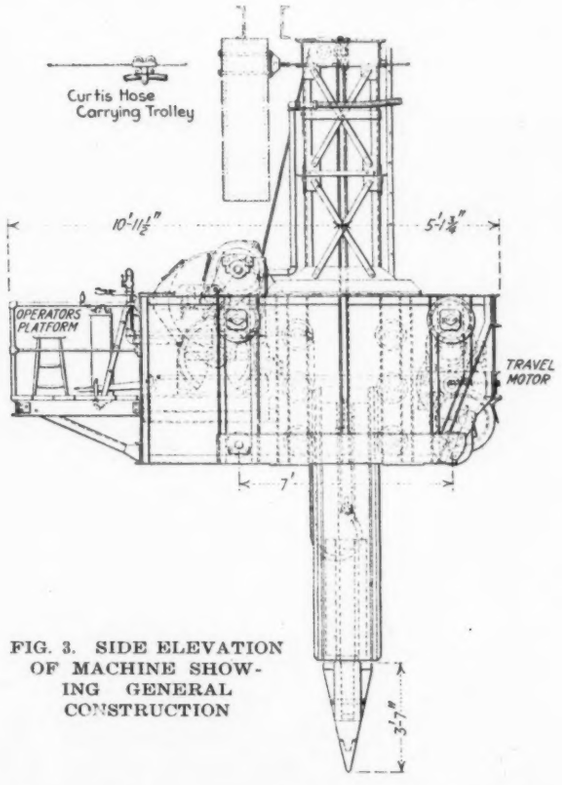


FIG. 3. SIDE ELEVATION OF MACHINE SHOWING GENERAL CONSTRUCTION

variable-speed motor. The hoist motor is provided with a solenoid brake, and there is a limit device to prevent overhoisting.

In Fig. 1 the spuds are shown lowered to a position at which the elevation of the lower ends corresponds to the height of the car floor. When the machine is not operating the spuds are carried at their highest position, the lowest extremity being on a line with the bottom of the carriage.

When a car of frozen coal is to be unloaded it is run over the track hopper and the doors opened. The machine is then moved to a point directly over the doors of the car. The spuds are lowered onto the coal and the air hammers put into operation. After a passage is made so that the coal drops through the doors, the spuds are sufficiently heavy to slice off the remaining coal without the use of the air hammers. The carriage is run backward, the spuds lowered into the coal and the carriage is then run forward, scraping the coal toward the doors and dropping it into the hoppers below.

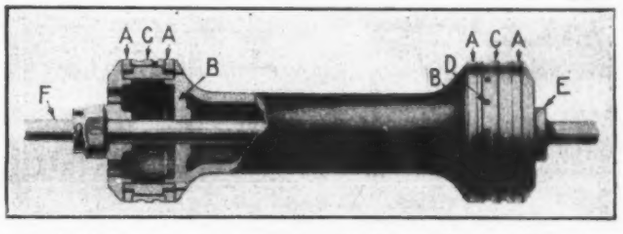
Under summer conditions it is not necessary to use the air hammers. As shown in Figs. 1 and 2, the bottoms of the spuds are cut out at the inner side, thus allowing them to clear the center beam on hopper-bottom cars. In working on flat-bottomed cars a small portion of the coal escapes through the opening between the spuds, but this is negligible in amount and can be removed quickly with shovels. Fig. 3 is a drawing showing the construction a little more plainly than the photographs.

Although the machine was designed principally for breaking up frozen coal during the winter months, it has proven efficient in unloading flat-bottomed cars during the summer months. To unload these cars with two sets of doors, one hour is required, with four men shoveling. The machine will do this same work in six minutes. The hopper-bottomed cars under summer conditions are practically self-unloading after the doors have been opened; but when unloaded by hand under winter conditions they require more time than do the flat-bottomed cars.

The machine has been operated since May, 1914, and the results have been very satisfactory. It was invented by the writer, who is an assistant engineer with the Detroit Edison Co. and was built by the Brown Hoisting Machinery Co., of Cleveland, Ohio.

Reeves Adjustable Piston Valve

The latest type of automatic piston valve made by the Reeves-Cubberley Engine Co., Trenton, N. J., is illustrated herewith. It is so designed that any wear of the piston rings and valve seat is taken up by the elasticity of the snap rings *A* and by the method of steam packing through the steam port *B* beneath the rings. The snap rings are locked into the middle, or expansion, ring *C*, so as not to wear the bridges in the ports, as the snap rings cannot move out farther than the outside surface of the



DETAILS OF THE ADJUSTABLE PISTON VALVE

expansion ring. The snap rings are on the bridges in the ports, and the expansion ring is on the solid portion of the valve seat.

The expansion ring is perforated with a series of small holes *D* to allow the steam pressure to equalize on both sides of it. In case of a slug of water coming to the valve, the wide expansion ring *C* collapses before the pressure can equalize and carries with it the two narrow rings *AA*, thus relieving the valve seat and cylinder.

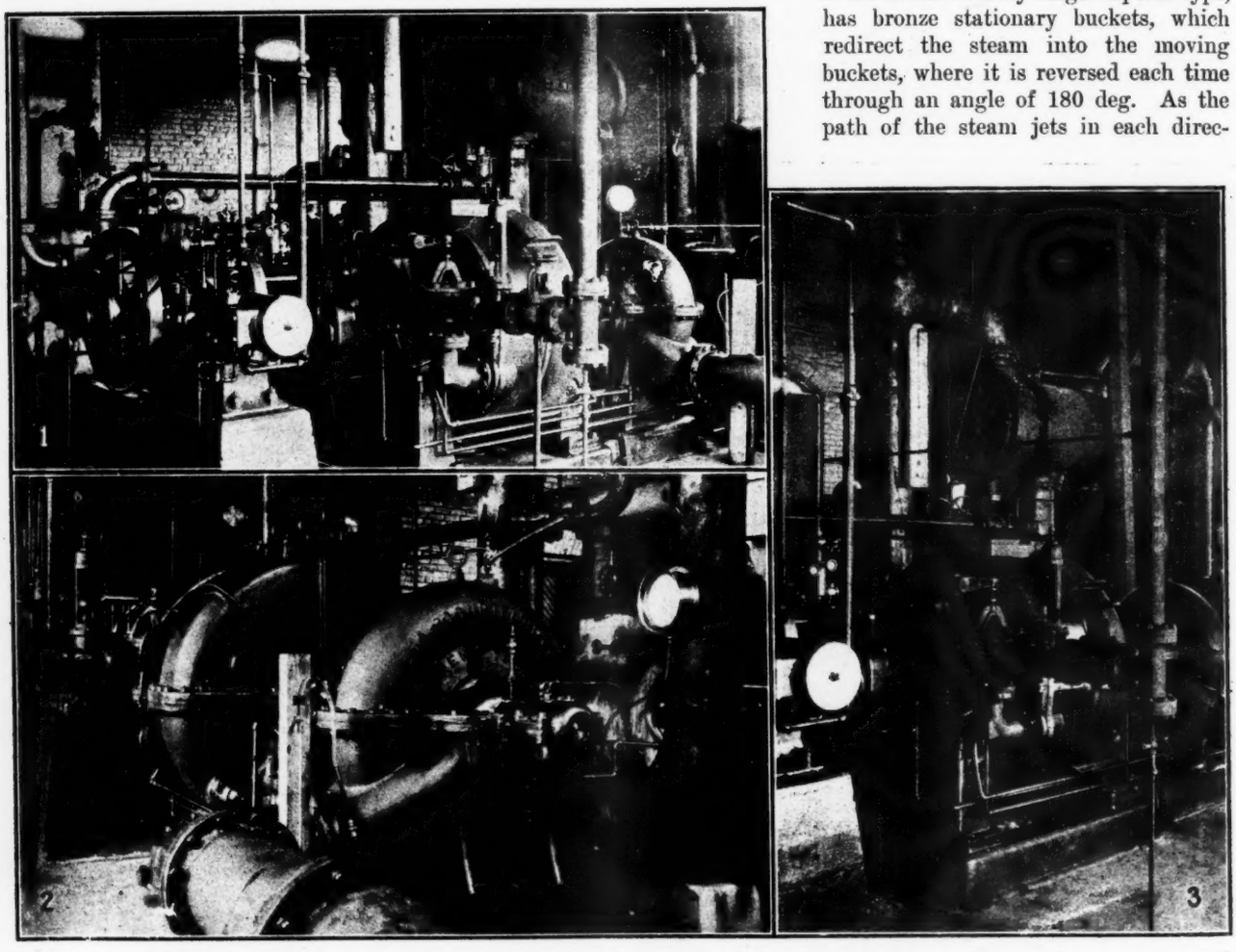
The expansion ring serves as a packing ring as well. All of the rings have an initial tension and are made eccentric in form. The weight of the valve in horizontal engines is carried on the valve stem *E* and the tail rod *F* in bearings, and so the tendency to wear the valve or seats out of round is reduced. The split in each snap ring is closed by a section of steel ring to prevent steam from blowing through.

Turbine-Driven Water-Works Plant

By C. O. Thomas

SYNOPSIS—A turbine-driven pumping unit displaces a pumping engine of 2,400,000-gal. capacity per 24 hr. The new pump has a capacity of 2400 gal. per min., or 3,456,000 gal. per 24 hr., against a head of 170 ft., with a speed of 2100 r.p.m.

The pumping plant of Charlottetown, P. E. I., consisted until recently of a pumping engine, installed in 1888, with a capacity of 2,400,000 gal. per 24 hr. This pump took its water from a large open well near the station, and in dry weather was supplemented by twenty-five driven wells at North River. To meet the increased demand for water and the requirements of fire service, the Commissioners of Sewers and Water Supply decided to purchase a modern pumping equipment of increased capacity, and on the recommendation of the consulting engineers, R. S. and W. S. Lea, of Montreal, it was determined to equip the station with steam turbine-driven pumping machinery.



DIFFERENT VIEWS OF THE TURBINE-DRIVEN PUMPING UNIT FOR CHARLOTTETOWN P. E. I.

Fig. 1—The main unit. Fig. 2—Showing construction of the pump casing. Fig. 3—The condenser is placed above the turbine and pump

The main pumping unit (Fig. 1) consists of a 10-in. double-suction single-stage volute pump directly connected to a high-pressure Terry turbine mounted upon a common bedplate. The normal capacity of the pump is 2400 gal. per min., against a head of 170 ft. when running at 2100 r.p.m. In the event of fire the head can be increased to 230 ft. by speeding up the pump. The pump casing (Fig. 2) is split horizontally and can be easily opened for inspection without breaking any pipe joints.

The turbine at present takes saturated steam at 90 lb., but by a slight alteration in the nozzles can be arranged for 150 lb., which pressure will be used in the future. Exhaust takes place at 27½-in. vacuum. The turbine, of the multi-velocity-stage impulse type, has bronze stationary buckets, which redirect the steam into the moving buckets, where it is reversed each time through an angle of 180 deg. As the path of the steam jets in each direction is at right angles to the shaft, there is no end thrust. The governor, mounted on the end of the main shaft, operates directly a double-seated balanced throttle valve, so arranged that should a spring break the valve will instantly close. Oil is supplied to the bearings by a gear pump driven by a worm on the main shaft, and before being returned to the bearings is cooled by water circulation in a large reservoir between the turbine and main pump.

The surface condenser is of the water-works type, built to withstand a water pressure of 100 lb. per sq.in., the 1-in. tubes being of brass. The discharge from the main pump passes through the condenser under all conditions of operation. To save floor space the condenser (Fig. 3) is placed about five feet above the center of the unit, the circulating water entering at the bottom of the shell and leaving at the top. A 10-in. exhaust pipe and expansion joint connect the turbine with the top of the condenser, the pipe being continued upward to an angle-type automatic atmospheric relief valve for noncondensing working, when a 10-in. gate valve cuts off the exhaust steam from the condenser.

The rated vacuum of 27½ in. is maintained by a Mullan vacuum pump (Fig. 1), which is equipped with spiral metallic flap valves, which are the only ones in the pump. They are water-sealed by the condensate, and are tight against back leakage of air. This result is attained by the air cylinder proper being within an outer cylinder, at the highest point of which the discharge outlet is placed, the annular and end spaces between the two cylinders being consequently filled with the water of condensation, into which the valves discharge. The air cylinder liner, piston, and valve decks are of hard brass, the tension of the phosphor-bronze valves on their seats being adjustable by a pawl and ratchet device on the end of each valve rod. The piston rod is of tobin bronze. Two flywheels, one on each side of the pump, insure a proper flywheel effect, and a governor of the throttling type is fitted for speed adjustment while the pump is in motion. The vacuum actually attained under load after installation was 28¼ in. when discharging the condensate against a head of 8 ft.

The present boiler, installed about seventeen years ago, is not capable of carrying a greater pressure than 90 lb. The plant will therefore not be working to its best advantage until a new boiler is put into service at 150 lb. pressure. The boiler-feed pump is of the duplex outside end-packed type, capable of working against 150 lb. pressure, and together with the air pump exhausts into an open feed-water heater, placed so as to give a head of 8 ft. on the feed-pump suction. The feed-water heater is rated at 150 hp. and acts as a feed-water purifier and filter, oil being abstracted from the exhaust steam by a separator integral with the heater. The air pump discharges the condensate into the heater at a temperature of 82 deg. F. under present working conditions, and the exhaust from the air and feed pumps is sufficient to raise the feed water to 165 deg. The actual heat saving effected by utilizing this exhaust only is therefore approximately

$$100 \times \frac{165 - 82}{1187 - (82 - 32)} = 7.3 \textit{ per cent.}$$

The figure 1187 represents the total heat in the steam at a pressure of 90 lb. This percentage in future will be increased by turning into the heater the exhaust from other engines, not connected with the main pumping unit. The actual net B.t.u. used by the air pump corresponds to ½ of 1 per cent. of that used by the main pumping set, and the saving in steam consumption effected by condensing over noncondensing working is about forty-five per cent.

Scrap in Power House—A Chicago wrecking company recently salvaged about 2000 tons of old iron and steel by the tearing down of the power house of the Philadelphia Rapid Transit Co.

JUST FOR FUN

Two Ways at the Same Time

A stuttering gang boss engaged in lowering some heavy machinery down a steep 75-ft. incline was naturally a little nervous. At a point where the load needed a little cautious urging he sputtered out "P-p-puh-puh-pup-pup-push-but huh-huh-hold back!"—Geo. H. Wallace, Racine, Wis.

Wanted to Save Current Perhaps

In a plant where I was employed, a green handy man had an extension light in his hand, and every now and then it would light up and then go out. Someone asked him what he was doing and he replied that he was trying to turn the light on half way.—Edward O. Edney, Birmingham, Ala.

Is the Worst Yet to Come?

One of our local citizens purchased a threshing outfit and, after running it for awhile, confided to a friend that the engine leaked steam where the shaft ran in and out of the cylinder and he did not know what to do about it. The friend suggested packing the stuffing-box, but the thresherman's face was a blank, indicating total ignorance as to the meaning of the suggestion.—R. E. Keech, Saranac, Mich.

Unexpected Results a Plenty

In the backwoods there are in use a great many obsolete types of engines operated by as antiquated an organization as can be imagined. In one instance it became necessary to remove the piston rod from the crosshead. Being a keyed tapered fit, the key was removed and after several ineffectual attempts to withdraw the rod, the man of all knowledge, the "sawer," proceeded to block the flywheel, and then he opened the throttle. It was his intention, he afterward stated (when revived), to just loosen the fit. The results were successful and more. The rod with the piston came out of the cylinder and flying about fifteen feet knocked the main supporting post from under the mill roof.—John F. Hurst, Louisville, Ky.

Too Much Pressure on the Gage Glass

An inspector making an external inspection of a boiler in a small plant asked the engineer to blow down the water column, so as to ascertain the condition of the openings through the connections to the boiler. After this had been done the inspector noticed that the water did not return freely to the gage glass. He therefore instructed the engineer that at his earliest opportunity he should clean out the connections, as no doubt sediment or scale was the cause of the water not returning freely.

"That's not the trouble," stated the engineer. "I have the water glass valves nearly closed, because the openings to the glass are too large with them wide open. I have been having so much trouble with glasses breaking, I keep them nearly closed so that there won't be so much pressure on the glass."—C. E. Kling, Philadelphia, Penn.

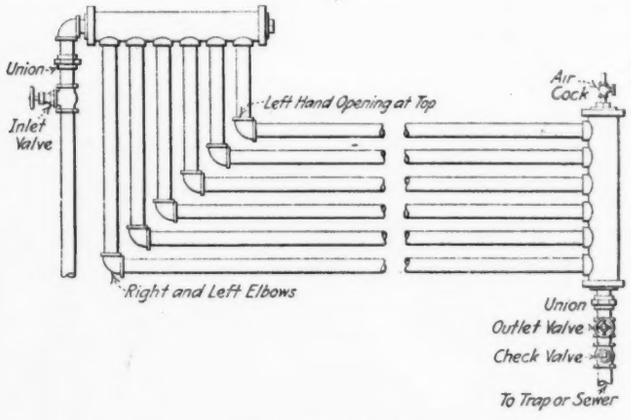
Miter Coils for Exhaust Steam Heating

By A. G. Solomon

Exhaust steam has sometimes proven a failure for heating because of the construction of the coils. For live-steam heating, a coil built up of 1¼-in. pipe and return bends is generally used. Such a coil gives enough heat with live steam, but will not when exhaust steam is sent through it.

In one plant a number of return-bend coils, each containing about 500 ft. of 1¼-in. pipe, were supplied with live steam. It was decided to use exhaust steam, and an exhaust header to which each coil was connected was run through the factory. The pressure carried was about 6 lb., but the coils would not supply sufficient heat. The back pressure was then set at 10 lb., but the result was still unsatisfactory. Live steam was again used, and the exhaust turned out to the atmosphere.

A steamfitter then convinced the management that the trouble was in the coils and that a great saving could be made provided the proper coils were used with exhaust steam. The return-bend coils were therefore replaced by miter coils built up of 2-in. pipe. When these coils



FITTINGS ASSEMBLED IN MITER COIL

were connected to the exhaust header, 6 lb. pressure supplied sufficient steam for heating. This goes to show that for exhaust-steam heating a miter coil will give good service where a return-bend coil will not.

It is an easy matter to build a miter coil if a little common sense is used. The headers or branch tees can be purchased or else made of tees and nipples. For a 2-in. coil six pipes high, the headers should be made up of 2½- or 3-in. nipples and of tees with 2-in. branch openings. The inlet should be not less than 2 in.

The headers should all be right-handed and the elbows right and left, with left-hand opening looking up as shown in the accompanying illustration. To make one of large size, say 75 ft. long, the hangers should be first placed so that the coil will have a fall of about 1 in. for every 20 ft. length. This will insure good drainage and reduce friction.

Make up the pipe into the vertical header first, taking accurate measurements when elbows are connected. The openings in elbows and in the headers must be the same distance apart. The shortest upright pipe is usually from 3 to 6 ft. long. Both the upright and horizontal pipes have left-hand threads on one end and right-hand on the other. The same number of threads must be cut on each end, so that both will be tight when pulled up. Count the threads when cutting and try a fitting on each.

The horizontal header is now either tied up or held in place, and the longest upright is screwed up tight, thus connecting the lowest horizontal pipe of the coil to the inlet header. To get the next upright in, this bottom pipe must be blocked or held up from the hanger, giving room to place the next upright in position. When in place, let the bottom pipe down again, and the weight will hold the second upright in place so that the threads can be easily started. The rest of the uprights are put in similarly, always lifting on the bottom pipe of the coil to get the necessary room between the header and the elbow. Any other way of assembling uprights will be troublesome and cause cracked fittings and crossed threads. A union is placed between the inlet valve and the header, so that the coil can be disconnected.

The outlet should be a 1-in. pipe and should have a valve to regulate the condensation flow. If several coils are connected into one outlet header, the check valve is put between it and the regulating valve. The check valve must also be used if a steam trap is installed.

Large-sized miter coils are often built with the headers of drilled and tapped pipe. Headers of 6-in. extra heavy pipe should then be used for a 2-in. coil. The greatest care must be taken to get the holes drilled in line, tapped straight and to the same depth. A pipe tap with an extension of not less than 12 in. is best. A square can then be used to see that the tap enters straight.

When changing a heating system from high-pressure to exhaust steam, the pipe surface must be increased, as the heat in the steam is less with the lowered pressure. The exhaust header must also be large enough for the increased volume of steam at the lower pressure. The miter coil can be used with exhaust steam with pressures as low as 2 lb., when a straight coil would soon fill with condensation.

A Difficult Smoke-Stack Job

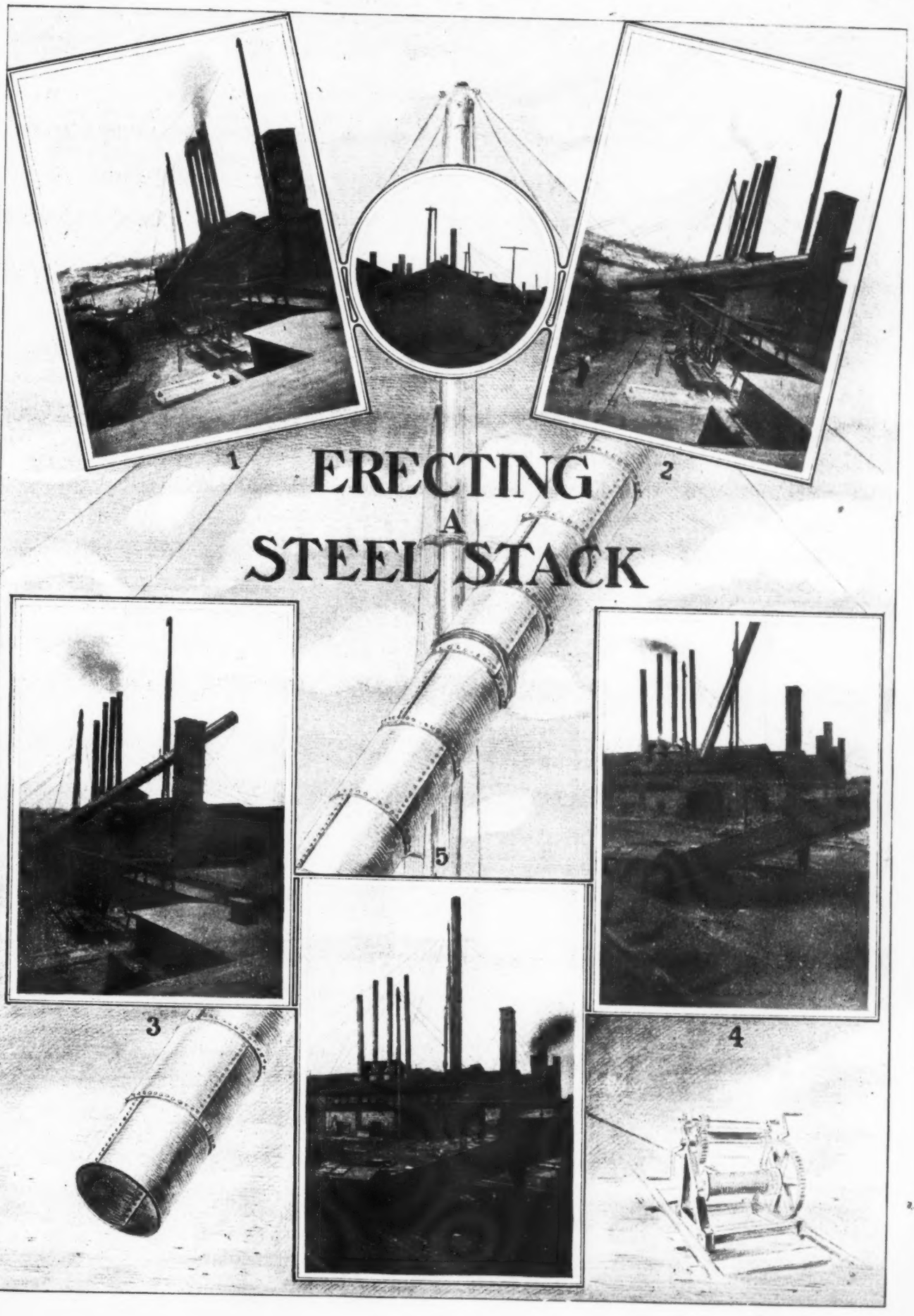
By F. L. Johnson

The photographs herewith show the method of erecting a 5x120-ft. smoke-stack weighing nine tons, as it was done at the Perth Amboy Works of the National Fireproofing Co.

To get it into place, it had to be carried over the roof of the boiler house. Two poles were used, one on each side of the building. Fig. 1 shows the first step, raising the stack clear of the ground and building on the shorter of the two poles, guy lines holding it away from the eaves.

Fig. 2 shows the stack lying across the roof with the hitch made from the taller pole, and in Fig. 3 the hitch from the shorter pole is moved nearer to the bottom and the stack made ready to be moved over the building. In Fig. 4 it is hanging freely from one pole, where it has only to be raised so that the bottom will clear the ridgepole, when it can be swung vertically by the guys and lowered into place, and Fig. 5 shows this accomplished.

This work was done under the direction of F. E. Sherwood, superintendent of boiler erection for the Heine Safety Boiler Co.


ERECTING
A
STEEL STACK
1
2
3
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5

Visits of Inspector Brown--VII

By J. E. Terman

SYNOPSIS—The Chief takes Brown to investigate the peculiar action of a pop safety valve. The location of the valve is discovered to be the cause of the trouble.

"Brown," said the Chief one morning, "get your grip and rig and come with me. The John Marsh Co. is having trouble with a new safety valve that was put on their old boiler."

Arriving at the plant they met the engineer, who said something would have to be done to the valve on No. 1 boiler, and done quickly. The Marsh Co. always ran on the ragged edge and never spent a dollar unless it was absolutely necessary. One of the boilers was old and allowed a pressure of but 110 lb. It was impossible for some of the engines, scattered throughout the plant, to pull the load placed upon them with a steam pressure less than 100 lb. Boilers Nos. 2 and 3 had been recently added to the plant, in place of an old one, a mate to No. 1, and the management had been advised to install all new boilers at the time of making the change, but gave the usual excuse of lack of funds. At an inspection made a short time before, the lever safety valve on No. 1 boiler had been found with a 4-in. elbow on the lever in addition to the regular weight to help keep the valve on its seat. The insurance company had required that this valve be replaced by a modern pop valve.

The engineer said that he was opposed to placing a pop valve on No. 1 boiler and that his judgment had been vindicated by the action of the new valve. He also said that on account of the low pressure allowed, it was necessary to carry steam right up to the popping point all the time, and when the new valve came off its seat it seemed as though it was never going to get back again, and it spit and sputtered at every stroke of the main engine, and he knew that it would pound itself to pieces if something wasn't done to stop it.

All three walked into the boiler room just as the safety valve on No. 1 boiler started to blow. It blew vigorously for a few seconds the way a valve of this type is supposed to operate and then began to sputter and spit, the banging to and opening of the valve keeping in step with the strokes of the main engine, which was located in the adjoining room. After the fire-doors had been opened the pressure was reduced to a point where the valve finally closed and remained closed.

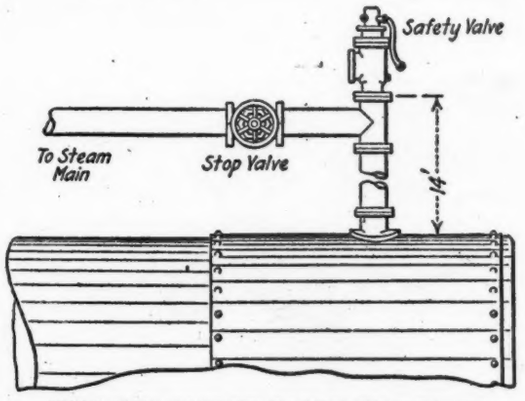
"Well," said the engineer to the Chief, "what do you think of that valve?"

No. 1 boiler was a horizontal return-tubular; the other two, newly installed, were water-tube boilers of the vertical type and required a much higher room. At the time the changes were made a new boiler house was put up of sufficient height to accommodate the new boilers and a new steam-pipe system was installed much higher from the floor than the old mains, in order to accommodate the higher boilers. In making the steam connections from the No. 1 boiler fit into the system, the vertical section of pipe on top of this boiler had been increased from about 2 to 14 ft. in length, and the new pop safety valve had been placed on top of a tee on the upper end of this pipe, in the same relative position that the old valve had occupied. The illustration shows the piping on No. 1 after the changes at the plant were made.

"I don't think there is anything the matter with that new safety valve," said the Chief, answering the question of the engineer. "It needs a little adjustment, but you can never hope to have it work entirely satisfactory unless its location is changed."

"I can't see what is the matter with its location," replied the engineer, "for it is in the same place occupied by the old valve and that always operated satisfactorily."

"Yes," said the Chief, with sarcasm; "its operation might have been satisfactory to you for what you wanted. I should judge from the way we found the old valve weighted that you never wanted it to blow. The difficulty with the new valve is that it is not located the same as the old one, which was bad enough, but it has been placed at least twelve feet further away from the boiler; it is also adjusted to close too soon after blowing. That is, there is not enough blow-down allowed.



HOW THE SAFETY VALVE WAS PIPED

"If you will get up there, Brown, remove the screw in the side of the case and turn the blow-down ring up, I think the trouble will be largely remedied, but the only way to make the valve operate as it should will be to place it directly on the shell of the boiler."

Brown got up on top of the boiler and adjusted the blow-down ring as directed by the Chief and then returned to the boiler-room floor, and steam was raised to try the operation of the valve. When it blew, its action was much improved and it closed permanently with only a slight kick or two.

"You see," said the Chief, "that valve is in almost the worst position that it could be in to prevent its working properly, for it is too far away from the boiler to work well and the location of the tee right under the valve makes matters worse. A safety valve should never be placed on the main steam connection to a boiler, especially when the steam is drawn from the boiler in puffs, as is the case when a reciprocating engine is used. While the drop in pressure due to the flow of steam

discharged from the safety valve and that passed to the steam main through the 14 ft. of pipe and the tee will not figure high in pressure, using the average rate of flow as a basis upon which to make the calculations, it has been demonstrated by practice that the momentary variations in pressure at the seat of a valve located in such a position are sufficient to prevent its proper operation, as we have just seen.

"A wider range in the adjustment between the opening and closing pressure will sometimes correct the trouble if the fluctuations in pressure are not too severe, but such adjustment should be considered only a temporary relief. The valve will be all right and work as it ought to if it is placed as near to the boiler as possible and on a separate connection which should be used for no other purpose."

Some Notes on Thermometers

By S. S. Rathbun

SYNOPSIS—Deals chiefly with some inaccuracies of mercury thermometers.

The mercury thermometer is the most frequently used in engineering work. The alcohol thermometer cannot be used for temperatures much above 150 deg. F., as it boils at 172 deg. F. As alcohol has a much larger coefficient of expansion than mercury, alcohol thermometers have the advantage of being much more sensitive than those using mercury.

Mercury freezes at —38.2 deg. F. and boils at 675.6 deg. F. at atmospheric pressure. Many thermometers, however, contain no air, the space above the mercury containing nothing but rarefied mercury vapor; consequently, the mercury, owing to the reduced pressure, will boil at a considerably lower temperature, and the upper limit of use is about 550 deg. F. There are "high reading" mercury thermometers made that will indicate temperatures up to 1300 deg. F. These have the space above the mercury filled with some inert gas, usually nitrogen. As the mercury expands, the gas is compressed and the pressure raised, hence the boiling point of the mercury is raised, and a high temperature is reached before there is any trouble due to boiling. The objection to these thermometers is that the glass is under considerable stress and is liable to break at the higher temperatures. Even if it does not break, it will expand and stretch slowly if kept at a high temperature for a long time, and on cooling the zero point will be found to be "off." For these reasons the practical limit of these thermometers is about 900 deg. F.

On any mercury thermometer there are several sources of errors, and to thoroughly understand these, it is necessary to know something of the methods of manufacture.

Mercury is poured in at *A*, Fig. 1, and is worked into the bulb *B* by alternately heating and cooling *B*, the heating driving out the air and the cooling drawing in the mercury. When stem and bulb are full the mercury is boiled to drive off the air that clings to the walls of the tube. The upper end is then fused off at *C* and sealed, the thermometer being at a temperature somewhat higher than the highest which it is to indicate. Due to a change that takes place in the glass after heating, a slight change will take place gradually in the level of the mercury at a given temperature. This is usually small—less than ½ deg. F. in the best thermometers—and extends over a long period. In all good thermometers this shrinkage of the glass after manufacture is prevented by annealing. If the thermometer is not annealed, the error may be as high as 40 deg. in 600. The positions of the top of the column for the fixed points, such as the boiling and freezing points for water, are determined, and the distance between these points is divided to read the temperature.

Some thermometers are graduated with the whole tube at the same temperature, and others are graduated with only the lower part, usually the lower 3 in., at the temperature to be measured.

If the thermometer is graduated with 3-in. immersion, i.e., with the lower 3 in. at the temperature to be measured and the upper part of the stem at room temperature, it is not necessary to make a stem correction if it is used with the lower 3 in. at the temperature to be measured and the remainder of the stem at the usual room temperature. With those graduated with the whole thermometer at the same temperature and used, as they often are, with the bulb at a high temperature and the stem at a much lower temperature, a stem correction must be made. The reason for this is seen when the fact is considered that nearly all of the mercury is in the bulb, the bore of the stem being small in comparison with the bulb. Hence, even when the stem is filled throughout its length and the temperature of the stem is far below that of the bulb,

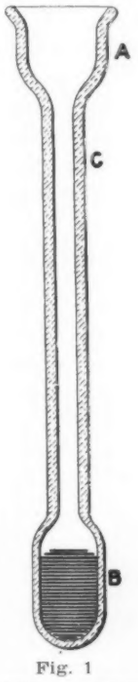


Fig. 1

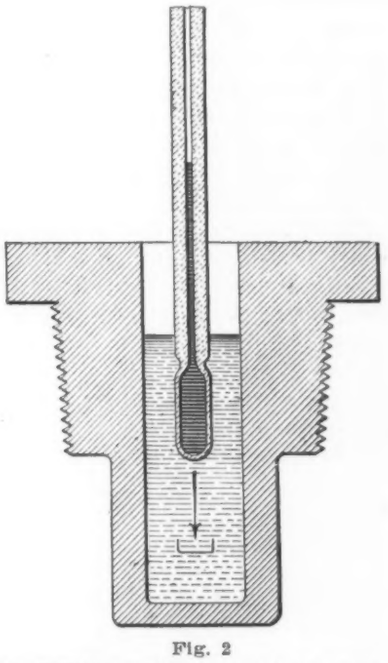


Fig. 2

FIG. 1. THERMOMETER TUBE BEFORE BEING SEALED
FIG. 2. THERMOMETER WELL

the average temperature of the mercury is nearly the temperature of that in the bulb, and the total volume of the mercury is practically the same that it would be if the stem were at the higher temperature. The glass of the stem, however, has not expanded, and the bore is smaller than it would be at a higher temperature, hence the mercury rises higher than it would if the stem were at the higher temperature.

The stem correction may be computed by the following formula:

$$stem\ correction = 0.000088\, n\ (t_2 - t_1)$$

where

n = Number of degrees of stem emerging in air;
t_1 = Average temperature of emerging stem;
t_2 = Temperature of bulb, i.e., the reading of the thermometer.

The correction with this coefficient is considerable at high temperatures. Thus, working with temperatures around 800 deg. F., it might easily be over 40 deg.

Thermometers are graduated by finding the position of the top of mercury column at certain fixed points and dividing the spaces between these points into equal parts to read in degrees, it being assumed that the bore is of uniform diameter. It will be found that the diameter varies in some thermometers, and a correction should be made. As this takes much time, and as it is not great in the better grades of thermometers, it is not made as often as the stem correction. If it is wished to make this correction, it is done by separating a part of the mercury from the rest by heating it with a gas jet, and by jarring it along in the stem and noting the variation in length. As this portion of the mercury lengthens out where the bore is small and shortens where it is large, it is possible to work out the corrections to be made.

The reading of a thermometer at the boiling point of water is easily made, but certain precautions must be taken. It is never safe to take the temperature of any vessel of liquid without thoroughly stirring, as the temperature will be found to be different at various points, and even with stirring it is hard to get an accurate reading, giving the average temperature. For this reason, in determining the boiling point the thermometer should not be immersed in the water itself, but should be placed in a specially constructed steam bath. Nor should the freezing point be taken by immersion in water which contains some ice, but by immersion in melting ice or snow.

Another source of error which some have reported as being considerable is that due to distillation. As has been stated, in the ordinary thermometer the space above the liquid mercury is filled with mercury vapor. When the temperature is much above 200 deg. F. the vapor is given off at a more or less rapid rate. If the upper part of the stem is cool, this vapor condenses in it, and may form a thread several degrees in length. As this effect occurs only where there is a difference in temperature between the upper part of the column of mercury and the portion of the stem above the mercury, it may be prevented either by cooling the column of mercury or heating the stem above the mercury. Perhaps, as a rule, the most convenient way would be to cool the mercury by putting waste previously dipped in cold water on the lower part of the stem. This way works satisfactorily up to temperatures around 400 deg. F. Above this temperature the high-reading thermometers should be used. In these, as previously stated, boiling is prevented by the pressure of a gas above the mercury. Besides the error mentioned, there are a number of others. The effect of capillarity of the tube may cause some error, also the pressure to which the bulb is subjected. A high pressure, of course, compresses the bulb and raises the level of the mercury. Glass, after being heated, does not return at once to its original dimensions, hence, after using a thermometer at high temperatures it will always be more or less inaccurate for a time. If the substance, the temperature of which is to be measured has but small volume, the heat capacity of the thermometer has an effect; that is, if the thermometer is colder than the material it absorbs heat from it and lowers its temperature before the final temperature is reached. These last mentioned errors are not of as great importance as the others, but they should be kept in mind where accurate work is to be done.

There are some special types of thermometers used commonly for specific purposes. One kind is used extensively in power houses. In this the glass bulb is protected against fracture by metal, and the heat is conducted from the metal to the case by mercury, which fills the space between the metal and the lower part of the thermometer. The mercury is prevented from leaking out by means of a packing that is a heat insulator and tends to prevent the upper part of the stem from gaining the higher temperature of the bulb.

As shown in Fig. 2, these thermometer wells are provided with threads and may be screwed into tapped holes in pipes carrying steam or other gas or liquid.

The scale of these thermometers is frequently placed on a piece of sheet metal located back of the stem.

A type of thermometer used for measuring the rise in temperature rather than the actual temperature has a reservoir at the top. The bore of these thermometers is small and a slight rise in temperature is sufficient to raise the top of the column the total height of the tube. This being the case, if it did not have the reservoir on the top it would be useful only for work where the temperature is within the given range. With the reservoir, however, if the thermometer has been used for high temperatures and it is desired to use it for low, a small amount of mercury may be added from the reservoir which will bring the level up to where it can be read. In changing back to read the rise or fall or temperatures through a higher range, a portion of the mercury thread must be detached and stored in the reservoir.

Synthetic Ammonia—The "Journal of Gas Lighting" (London) states that a process which allows of gas producers being utilized to manufacture ammonia by synthesis has been devised by Herr Adolph Bambach. By its aid atmospheric nitrogen can be fixed in the form of metallic compounds, both carbureted and nitrogenous (cyanides, cyanamides, etc.), or metallic nitrogen compounds (nitrides), and these substances decomposed, either with saturated or superheated steam or with water, to extract the ammonia.

The Victoria Falls of the Zambesi in South-Central Africa, it is stated on good authority, are capable of furnishing 35,000,000 hp. of electrical energy and probably not over from 25,000,000 to 30,000,000 hp. is employed in the world today from the direct or indicert use of oil or coal. There are three other great cataracts which so completely surpass all the rest on the score of power available that they are entitled to be grouped with the stupendous African phenomenon which the natives call "The Smoking Waters." This quartet of great cataracts—Victoria, Niagara, La Guayra and Iguassu—aggregating something in excess of 60,000,000 hp., represent between them from 5 to 7 per cent. of the power of all the rivers of the world.

Economic Selection of Prime Movers

By Reginald Trautschold

SYNOPSIS—The economic operation of the power plant depends greatly on the selection of units to meet best the given conditions. A small electric generating station is taken as an example and a method of selecting its most efficient prime movers outlined.

A cardinal point in power-plant design is that the power must be furnished as efficiently as the demand permits. Correct apportionment of the plant load to the various generating units is just as important as efficient operation. Furthermore, the engineer who lays out a plant should choose the power equipment with a view of allotting to each piece of apparatus the work it can perform most efficiently.

The probable power demand on a plant is, it is true, usually not accurately known. The plant must be in actual operation for some time before this can be ascertained, but an approximation can nearly always be made, for there are few plants erected that are not based to a greater or less extent upon the experience of others. What is required is an average load curve, decision as to whether steam, hydraulic or other power is to be employed and the kind of fuel, if the plant is to be operated by steam. With such data the selection of main power units and their proper operation is not a very difficult undertaking.

A concrete example will best show the preliminary analysis that should be made when constructing or remodeling a plant, so a certain electric light and power station may be taken as a good illustration. The average daily-load characteristic of the particular station chosen is shown in Fig. 1. This accurate load characteristic of course simplifies the problem, but knowing the possible current demand, it would be quite possible to deduce a similar curve. The station considered used compound steam engines and, as many plants are so operated, the problem will be attacked on the assumption that such power would be the most economical and advisable.

Study of Steam Consumption

Having decided upon reciprocating steam engines, their relative steam consumption under various loads must be studied. Fig. 2 shows the behavior of the average reciprocating engine. The full-load rating, when the engine is ordinarily most economical in the use of steam, is taken as 100 per cent. The curve is generally applicable, for irrespective of an engine's actual steam consumption, its relative efficiencies at various degrees of load are very nearly the same.

Ordinarily it is inadvisable to overload an engine by more than ¼ of its full-load rating. On the other hand, engines are frequently operated at less than ¼ load. If the latter is taken as the minimum under which it pays to operate, it is just as logical to fix 1½ load as the maximum the engine should be allowed to carry. The steam consumption is very nearly the same at either ¼ or 1½ load. This would give an allowable load range between maximum and minimum of 600 per cent. beyond which it would not be good practice to force the engine. If ¼ overload is taken as the permissible maximum, ½ load should represent the minimum, giving an allowable load range of but 250 per cent. Such a range is frequently not sufficient in installations where a second engine to care for the peak load would be of questionable economy. Probably the best practice is to take about 1¼ load for maximum and allow the minimum to fall slightly below ¼ load. When the load range is less than 250 per cent., the best practice, unless the peak is sudden and of short duration, is to have the steam consumption about the same at both minimum and maximum loads. For instance, with a load range of 150 per cent., the maximum demand on the engine should be about 14 per cent. overload and the minimum should be 76 per cent. of the engine rating at full load (114 divided by 76

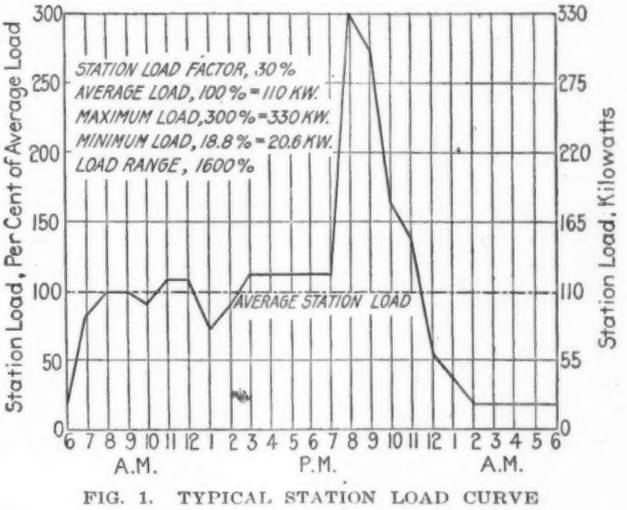


FIG. 1. TYPICAL STATION LOAD CURVE

equals 1.5). This relationship is more conveniently expressed in terms of the load factor, which is the ratio of average to maximum load during a given period. For a load range less than 250 per cent., the per cent. load factor multiplied by the maximum load, in fractional part of the full-load rating of the engine, will give the percentage relation between average-load and full-load rating. For load ranges from 250 to 600 per cent., the per cent. load factor multiplied by 1¼ gives the engine rating at average load.

Number and Rating of Units

From Fig. 1, one engine could not economically care for the whole range of load, which in this case is some 600 per cent. A second engine should be installed to care for the peak load between the hours 7 p.m. and midnight. In the calculations necessary to obtain the proper size of units it would be well to consider the station as consisting of two distinct power plants. One would handle only the peak, and the other would care for what may be termed the normal load of the station.

This gives a normal-load factor that is as high as possible without unduly decreasing the peak-load factor (see Fig. 3). The load factor of the normal division is 70 per cent. and the load range about 600 per cent., so that the engine rating at the 86.1 kw. average load is 87.5 per cent. (70 times 1¼). At full load, then, the economic generator to install should develop 98.4 kw. (86.1 divided by 87.5), say 100 kw. Such equipment at 1¼ rating would care for the heaviest of the normal load and during the hours from 2 to 6 a.m. would operate at only slightly under ¼ full-load rating.

A somewhat different procedure is necessary to determine the rating of the peak-load generating equipment. The load factor is known, but the minimum load is zero. As it is impractical to consider an infinite load range, the equipment rating must be based on the maximum demand alone. The maximum load being 206.3 kw., advisably at 1¼ of equipment rating, at full-load rating 165 kw. should be developed. This, however, would allow for little power reserve should a high peak be developed, so a 200-kw. generating unit should be installed, thus providing a 20 per cent. reserve. Such equipment would handle the maximum average peak at slightly above full-load rating and would be little, if any, more extravagant in the use of steam than the 165-kw. unit, even though the latter could balance the load more economically to its relative steam consumption. A small auxiliary generating unit of about 50 kw. capacity added to the station would prove exceedingly useful in times of trouble.

The efficient choice of generating equipment for this station would, then, be a 100-kw. generator to handle the normal load, a 200-kw. generator to care for the peak load and a spare 50-kw. unit for emergency. Each should be driven by a separate engine and the boiler plant laid out to supply most efficiently the steam for the various units. The use of the 200-kw. unit handling continuously the normal load of the station and a considerable share of the peak load and reserving the 100-kw. unit for the balance of the peak load would be possible, but this, as will be seen, would not tend toward economy in operation and would entail a considerably greater consumption of fuel than in the case of the more efficient arrangement.

Comparative Operating Economy

Before investigating the actual operation of the station and considering the changes that local conditions made advisable, further assumptions may be made to ascertain the waste should the larger of the two main generator units carry the normal load of the station. For simplicity we may assume that at full load the 200-kw. and the 100-kw. generating units are equally economical in the use of steam. This assumption is not unreasonable or impossible of realization with high-grade equipment. Let us arbitrarily fix the coal consumption at 3 lb. per kw.-hr. With the assistance of the curves the average daily coal consumption of the station, under the conditions assumed, can be easily found. But in calculating this consumption it should be remembered that the average steam consumption, which is obtained from the hourly kw. readings, differs considerably from the steam consumption under average load. The reason for this of course is that the steam consumption is far from being (see Fig. 2) proportional to the load.

We now have comparative consumptions for the two cases: (1) The 100-kw. generator handles the normal load and the 200-kw. unit helps out for the few hours' peak; (2) the larger machine is operated continuously and the 100-kw. unit only on the peak. At 3 lb. of coal per kw.-hr., the results when both units are permitted to carry 1¼ load are as follows:

Case	(1)		(2)	
Machine, kw.	100	200	100	200
Daily operation, hr.	24	4	3	24
Average load, kw.	86.1	93.1	102.2	57.0
Relative steam consumption, per cent.	113.3	125.5	101.4	123.5
Daily coal consumption, lb.	7024	1402	250	9083

These results show that the 100-kw. generating unit, when taking the normal and part of the peak load of the station, would consume about 1177 lb. less coal per day than would be necessary if the normal load was cared for by the 200-kw. unit and the current for all of the peak load supplied from the smaller generator. This decrease in coal consumption of about 14 per cent., at $3 per ton for coal, would mean that about $644 per year could be saved by the proper use of the equipment.

Results Actually Obtained

The generating equipment of the station, which was the light and power plant of the City of Palo Alto, Calif., consisted of a 200-kw. alternator driven by a cross-compound slide-valve engine, a 100-kw. alternator coupled to a similar engine, and a 50-kw. generator belted to a simple engine with Corliss valve gear. The large generator handled the average load of the station, and the small unit was employed only in emergency. This equipment, as brought out in the preceding analysis, would have proved, if properly operated, the most economical that could have been installed. This economy was not attained, however, because of conditions which either were not realized when the station was constructed or did not develop until later. The engines

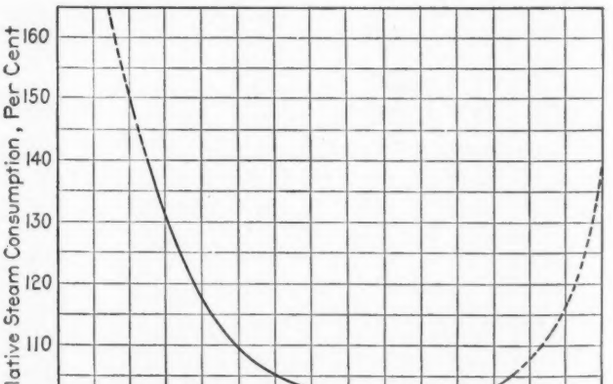


FIG. 2. SHOWING RELATIVE STEAM CONSUMPTION

proved wasteful in the use of steam and consequently in the consumption of fuel, which in this instance was California crude or fuel-oil instead of coal. It was deemed advisable to discard some of the old equipment and install apparatus of a more economical kind. This would have been advisable even had the old equipment been operated efficiently.

The first plan was to replace the old equipment with a 500-kv.-a. generator driven by a steam turbine operat-

ing condensing. The surplus capacity was to care for expansion in business. Such a unit could not be operated efficiently, however, under the existing demand for current, as the average requirement was only about 20 per cent. of its rated capacity. It was then decided to

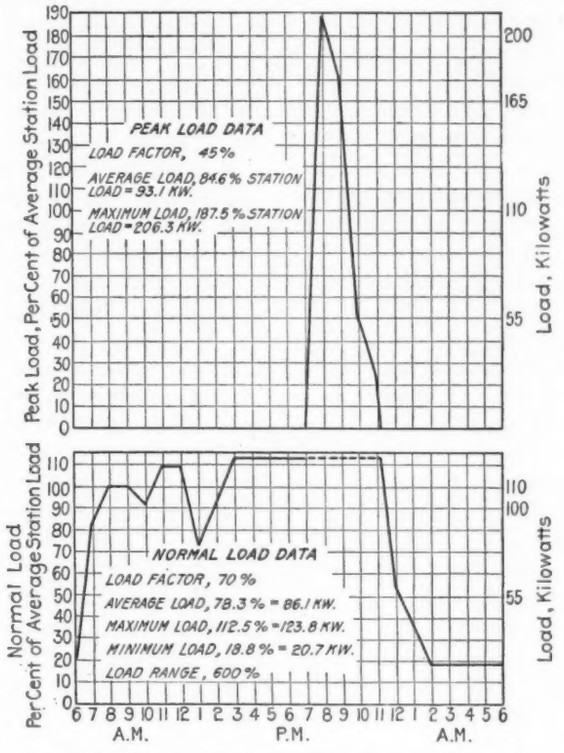

Peak Load, Per Cent of Average Station Load
Load, Kilowatts
PEAK LOAD DATA
LOAD FACTOR, 45%
AVERAGE LOAD, 84.6% STATION LOAD = 93.1 KW.
MAXIMUM LOAD, 187.5% STATION LOAD = 206.3 KW.
Normal Load Per Cent of Average Station Load
NORMAL LOAD DATA
LOAD FACTOR, 70%
AVERAGE LOAD, 78.3% = 86.1 KW.
MAXIMUM LOAD, 112.5% = 123.8 KW.
MINIMUM LOAD, 18.8% = 20.7 KW.
LOAD RANGE, 600%
A.M.
P.M.
A.M.

FIG. 3. LOAD SEPARATED IN PEAK AND NORMAL DIVISIONS

install an oil engine, whose proven fuel consumption under full load was less than 0.4 lb. of oil per b.hp.-hr. The old steam engine used more than 4 lb. oil per kw.-hr. delivered, or about 3 lb. of oil per b.hp.-hr.

The complete remodeling of the station for exclusive oil-engine operation would have been expensive and was not deemed advisable at the time of rebuilding. It was decided to retain one of the wasteful steam engines and to operate a combination steam- and oil-engine plant. The fact that an oil engine cannot be efficiently operated at much overload, led to an inefficient installation in order to secure an appreciable monetary saving.

To replace the wasteful 100-kw. steam unit would have required the installation of a 125-kw. oil engine, in order that the normal load might be cared for at all times without calling upon the peak-load equipment. While this would have resulted in considerable economy, the 200-kw. steam-driven unit handling the heavy load between 7 p.m. and midnight would have burned some 1500 to 1700 lb. of oil daily under the steam boilers. To minimize the amount of oil required, it was decided to install a 200-kw. oil engine capable of handling the normal load of the station and part of the peak load, to discard the 200-kw. steam unit and to retain the 100-kw. steam engine to care for the top of the peak. This arrangement would have been wasteful if only steam equipment had been employed, but even though the oil engine was operated inefficiently at light load most of the day, a further reduction of about 700 lb. per day in oil consumption was made possible. At 90c. per barrel, the average price of oil at the power station, the 200-kw. engine decreased the annual station-operating cost $6000 or $7000, a saving secured by the inefficient use of a very economical power unit.

Possible Storage-Battery Arrangement

It is of interest to discover if some other plan could have been followed with equal or better results. The curves (Fig. 1 or 3) show that the normal load of the station is by no means constant. In fact, to maintain constant the 125-kw. output required between the hours of 3 and 7 p.m., about 800 kw.-hr. more would be needed. The entire peak load totaled only about 400 kw.-hr. If storage batteries were installed so that the 125-kw. generator could be driven constantly at full load they would be sufficient to supply the current required for the peak load and still have available a considerable daily surplus for any emergency. The oil consumption of the 125-kw. oil engine, running at all times under full load, would be considerably less than that of the 200-kw. engine installed. The annual saving would be about $360 for 400 bbl. of oil. Doing away with the necessity of operating the 100-kw. steam-engine-driven unit used for handling the top of the peak would result in the saving of another 1,400 bbl. of oil per year, an economy of $1,260. The difference in cost between a 125 and a 200-kw. oil engine and between the two sets of foundations would be in the neighborhood of $3,500. Taking 15 per cent. of the latter amount as representing the annual saving in interest on investment, depreciation, renewals, insurance and taxes, the total saving of the storage-battery arrangement over that of the oil- and steam-engine composite plant, would be about $2,145, exclusive of any charges for new storage batteries. This yearly saving would be sufficient to pay a fair rate of interest on an issue of $50,000 construction bonds, an amount ample to pay for the storage batteries required.

The storage-battery arrangement might not have proved as satisfactory as the plan adopted, but the possible saving is so considerable that thorough study of such a method should have been made. An opportunity of saving $2000 a year should have meant more to the station management than the small sum necessary to investigate the plan.

The Internal-Combustion vs. the Steam Engine

It was in 1881 that the late Sir Frederick Bramwell prophesied that by 1931 the steam engine would only be seen as an interesting relic of a past age, having been superseded by the internal-combustion engine. The steam engine, as the result of over a century's improvement, was still so inefficient that it was an exceptionally good mill engine which required a supply of less than 15,000 B.t.u. per indicated-horsepower hour. The gas engine, hardly older in years than the steam engine in decades, was even in small sizes capable of developing an indicated horsepower from a heat supply of 12,000 B.t.u. per hour, a figure which was materially bettered in the case of larger units. That steam, thus beaten by the veriest upstart, was on the eve of obsolescence was a very natural conclusion.

The second year following Sir Frederick's prophecy saw, however, in the birth of the Parsons steam turbine an innovation in the use of steam which promises to postpone

for many years, possibly indefinitely, its fulfilment. The best internal-combustion engine at present known does not in practical operation convert into useful work at the shaft more than some 30 per cent. of the heat in the fuel it consumes, and requires, accordingly, about 8500 B.t.u. per shaft-horsepower developed. A Crossley engine, tested by Mr. Atkinson in 1905, is claimed to have shown a thermal efficiency of 36.9 per cent. The compression was 200 lb. per sq.in., corresponding to a clearance ratio of rather less than 1/6. With a clearance ratio of 1/5, which corresponds better with practice, the British Association Committee gives the highest efficiency theoretically possible as 38.4 per cent., so that the margin available for further advances is obviously very narrow.

On the other hand, the margin for possible improvement in the utilization of steam is still substantial. The extraordinary improvement which has already been effected is well illustrated by some figures compiled by Emil Garcke, showing the steam required per kilowatt-hour by successive installments of plant at the St. Pancras Power Station. In 1891 the 80-kw. reciprocating units had a steam consumption at full load of 25 lb. per kw.-hr. The last of these reciprocating units, rated at 450 kw., was installed in 1903, and on trial a water rate of 19.5 lb. per kw.-hr. was recorded. The first turbo-generator was erected in the station in 1906. This was a continuous-current machine and took 17 lb. per kw.-hr. In 1909 a turbo-alternator was erected having a steam consumption of 16½ lb. per kw.-hr., while the 5000-kw. Ljungström machine to be installed this year is guaranteed to develop 1 kw.-hr. for 11.8 lb. of steam.

Even the best of these figures does not constitute a record. For the 25,000-kw. turbine at Chicago a steam consumption of 11.25 lb. per kw.-hr., as measured at the switchboard, was guaranteed, and this figure has, we understand, been materially bettered on trial. Indeed, Mr. Ferranti, in his James Watt lecture, claimed to have obtained results with a unit of 5000 kw. equivalent to a steam consumption of under 6 lb. per shaft-horsepower hour. Such a water rate implies an expenditure of certainly less than 8000 B.t.u. supplied to the engine per shaft horsepower. Probably the figure quoted does not include the work of driving feed and circulating pumps and other accessories, and is undoubtedly dependent upon a very high vacuum in the condenser, which it is not possible to realize at all seasons of the year. Making, however, all allowance for these, it is evident that the thermodynamic advantage of gas over steam is steadily being reduced, and it is easy to understand, accordingly, why the Cockerill company just prior to the outbreak of the war was inclined in the projected extension of its power station to use the furnace gases under boilers to supply steam turbines rather than in internal-combustion engines.—*Engineering.*

Rubber-Belting Briefs—A Goodyear trade publication gives the following suggestions regarding the care and use of rubber belts: Belts should not run less than 200 ft. per min. Average velocity of belts should be 2,000 ft. per min. Maximum velocity of belt should be between 5,000 and 6,000 ft. per min. When running at high speed the centrifugal force of the belt has a tendency to remove it from contact with the pulley, thereby lessening the horsepower transmitted. All animal oils and grease are injurious to rubber belting. Shifters should not be used on rubber belting. Once the edges are worn through, the plies readily separate. Large face pulleys and normal speeds, proper tension and plies of fabric give best service.

What Commutator Appearance Indicates

By V. A. Clarke

It does not take an engineer to know that something is radically wrong when a motor or generator begins to spark badly and flash over, but it sometimes requires an expert to tell what is causing the trouble and how to remedy it. On the other hand, a machine may be running fairly smoothly, with little or no sparking, and yet be giving exceedingly unsatisfactory service from the standpoint of commutation. The appearance of commutators may be classed under one of the following heads: Raw, coppery color; bright, glossy finish; chocolate-brown gloss; dark-brown or black appearance.

A raw, coppery looking commutator always denotes bad operation and indicates that too abrasive a brush is being used, which is grinding the commutator down rapidly. If allowed to continue, the bars will have to be replaced in a comparatively short time. If the commutator is slotted, the slots will gradually fill up with copper dust, causing short-circuits which may burn out the windings. The remedy is obvious—use a brush containing less abrasive material.

Cases are often encountered, principally in the older machines, where the insulating mica between the commutator segments is very hard—harder, in fact, than the copper segments themselves. The copper therefore tends to wear away faster than the mica, and as this is a cumulative action, after a while the mica will project noticeably above the commutator surface and the brushes will make poor contact or sometimes no contact at all, causing poor commutation and disastrous sparking. As a remedy, commutator slotting has proved highly successful in many cases, but its value in some cases is questionable, and there are instances where it appears to be objectionable. In order to keep this high mica flush with the face of the commutator a brush must be used that will cut it away as fast as the commutator wears; these brushes are known as "abrasive."

The terms "hard" and "abrasive" must not be confused. The bottom of a glass inkwell is hard, yet it will not scratch a desk, while a much softer piece of sandstone will take off all the varnish, because of its abrasiveness. Hard brushes are always desirable, since they wear much longer, but abrasive brushes wear both themselves and the commutator rapidly; hence, where they are necessary the minimum abrasiveness required should be sought. Theoretically, a brush can be made just abrasive enough to keep hard mica down without cutting the copper perceptibly. This would give the commutator a rather brown, glossy appearance. In practice, however, it is difficult to obtain a brush of the exact composition required for any particular machine, and one of a little higher abrasiveness is generally used. The commutator will then remain bright, but will take on a high polish. It will be evident that this is a compromise, but the operation is satisfactory, though the commutator will wear perceptibly in time.

Many operating engineers and electricians believe this bright, glossy surface denotes the ideal operating condition. As a matter of fact, except in the case cited, where there is high mica to contend with, it usually indicates unnecessary wear of both commutator and brush.

Suppose we disassemble a direct-current motor or generator, remove the armature and set it up in bearings, then revolve it under a hard nonabrasive brush. The commutator will soon take on a bright gloss if the operation is perfect. Now, if current be passed through the brush into the commutator, its color will darken considerably. To this extent then, the advocates of bright commutators are correct—perfect operation of the brush against copper will produce a bright glossy surface, but only when no current is flowing. On machines in service the same perfect operation will give a chocolate-brown gloss. The chocolate color is no doubt produced by some carbon deposit on the commutator, but the quantity is so minute that the thickness of the film cannot be measured; it is probably an alloy of copper and carbon. After the glossy film has once formed, there is no further deposit or alloying, so that the film becomes no heavier. Hence there is no tendency to fill up the slots of slotted-commutators or to cause flashovers if unslotted.

The chief advantage of operating so as to keep the commutator in such a condition is that it indicates the minimum possible wear of both commutator and brush. A lesser advantage is the fact that, being darker, it radiates heat faster than a bright surface and thus keeps the commutator cooler.

If too soft a brush is used the commutator will become darker and darker, taking on a gummy appearance caused by heavy deposits of carbon or graphite from the brushes. This condition is especially to be guarded against. From the operating standpoint it is bad, because it fouls the commutator, fills up the slots (if the commutator has been slotted) or bridges across the mica, causing flashing-over, heavy sparking and short-circuits. From the brush standpoint it is almost equally bad, since the brushes will wear rapidly. The obvious remedy is to sandpaper the commutator, clean out the slots and use a harder brush.

Operating experience, as well as theory, thus indicates that best commutation and longest brush life occur when commutators are kept on the middle ground between a bright glossy surface and a dull-black one—that is, a glossy chocolate-brown.

Flow of Air and Steam Through Orifices

By A. L. Westcott*

SYNOPSIS—Results of experimental determination of coefficients applicable to Fleigner's formula and the theoretical formula for the flow of a fluid through an orifice. Applied to air, the method may be used to measure the output of an air compressor, and to steam for measuring the consumptions of auxiliaries.

The flow of air, in pounds per second, through an orifice having a well-rounded entrance, is given by formulas deduced by Fleigner and stated as follows:

Let

p_1 = Pressure in pounds per square inch above the orifice;
p_2 = Pressure below the orifice;
a = Area of orifice in square inches;
T_1 = Absolute temperature of air above the orifice;
W = Weight of air in pounds per second, flowing through the orifice.

Then,

$$W = 0.53\, a \frac{p_1}{\sqrt{T_1}}, \text{ when } p_1 \text{ is greater than } 2\, p_2 \quad (1)$$

$$W = 1.06 \sqrt{\frac{p_2 (p_1 - p_2)}{T_1}}, \text{ when } p_1 \text{ is less than } 2\, p_2 \quad (2)$$

These equations were based upon experiments by Fleigner with orifices having well-rounded entrances. In the case of an orifice having sharp edges at entrance, a coefficient of discharge less than unity must be included as a factor, and formulas (1) and (2) become,

$$W = 0.53\, ka \frac{p_1}{\sqrt{T_1}} \quad (3)$$

$$W = 1.06\, ka \sqrt{\frac{p_2 (p_1 - p_2)}{T_1}} \quad (4)$$

If the drop in pressure is very small, it is best measured by means of a manometer. If h represents the pressure drop in inches of mercury, equation (4) becomes,

$$W = 0.742\, ka \sqrt{\frac{p_2 h}{T_1}} \quad (4a)$$

For the flow of air from a reservoir into the atmosphere, p_1 being greater than $2p_a$, formula (3) may be used, and if a form of orifice is used for which the coefficient k is accurately known, this is a good method of measuring the output of an air compressor when being operated for the purpose of testing. If the air is to be used, however, only a small drop in pressure is permissible. An orifice placed in a pipe line in this case should be of sufficient size to accommodate the quantity of air flowing without more than a small loss of pressure.

Instead of the preceding formulas based upon Fleigner's investigations, the theoretical formula for the flow of a fluid through a nozzle or orifice may be deduced. The velocity of approach of the air being small enough so that the resulting velocity head may be neglected without appreciable error, the velocity through the orifice is expressed by the formula,

$$V_o = J \sqrt{\frac{2g (p_1 - p_2) 144}{s}} \quad (5)$$

Where,

V_o = Velocity of air through the orifice in feet per second;

*Assistant professor of mechanical engineering, University of Missouri.

s = Weight of air in pounds per cubic foot, at an average density above and below the orifice;

f = Coefficient of discharge for this formula,

$$W = \frac{V_o a s}{144} = \frac{f a}{144}\sqrt{2g(p_1 - p_2)144\,s} \qquad (6)$$

If the difference in pressure $(p_1 - p_2)$ is expressed in inches of mercury and 64.4 is substituted for 2g, equation (6) reduces to the following:

$$W = 0.4681 f a \sqrt{hs} \qquad (7)$$

For air, $s = \frac{144\,p}{53.3\,T}$

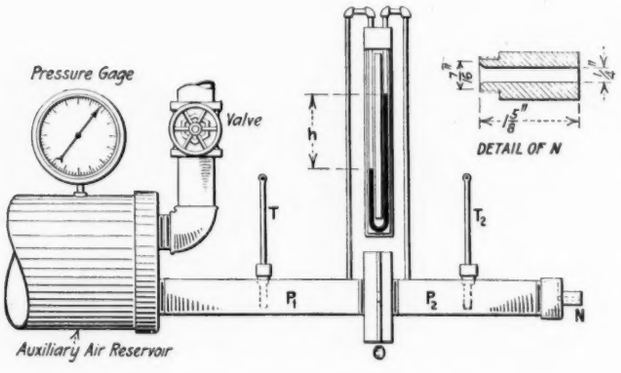
p = Average of initial and final pressures in pounds per sq.in.

T = Average of initial and final absolute temperatures in deg. F.

Substituting this value for s, equation (7) becomes:

$$W = 0.770 f a \sqrt{\frac{hp}{T}} \qquad (8)$$

The sketch shows an apparatus made by the writer, for laboratory instruction, in which air from a large receiving reservoir of a two-stage air compressor is permitted to flow into a small auxiliary reservoir, thence through a short 2-in. pipe in which is placed a circular orifice with sharp edges O. The air then flows through a short tube N, shown enlarged in the detail and into the atmosphere. For a short tube of this form, having a rounded entrance, Weisbach gives a coefficient of discharge of 0.92 to 0.93 when applied in equations of the Fleigner form, as (3) and (4). An average value of 0.925 was used in the experiments with this apparatus.



DEVICE FOR MEASURING FLOW

Table 1 records the observed and computed data of a series of tests with air at different pressures. Temperatures were observed above and below orifice O. The rate of flow was computed from formulas (3) and (4) applied to the tube N. The weights of air being in each case thus exactly determined, formulas (4a) and (8) were in turn applied to the orifice O, the purpose being to ascertain for each the values of the coefficients k and f.

Diameter of short tube N = 0.251 in.
Area of short tube N = 0.0494 sq.in.
Diameter of orifice O = 0.539 in.
Area of orifice O = 0.2281 sq.in.

The average value of 0.602 found for f is in close accord with values found by Durley, reported in the "Transactions of the American Society of Mechanical Engineers," Vol. 27, for the flow of air through orifices under similar conditions.

Flow of Saturated Steam Through an Orifice

An orifice of the proper size so that the drop in pressure is small, is a convenient and practical means of measuring the flow of steam in a pipe. If the equipment includes a mercury-filled manometer arranged to show accurately the pressure drop and if the flow of steam does not fluctuate rapidly, the degree of accuracy is adequate for measuring the steam consumption of auxiliary apparatus such as air and circulating pumps and boiler-feed pumps. The drop in pressure being small and the density of the steam therefore being little changed in passing through the orifice, a rational formula for the rate of flow can be developed and used. Formula (6) is general and applicable to any fluid of density s. In the case of steam, with the manometer connected as shown in the sketch, the space over the mercury will be filled with water up to the level where the condensed steam will drain back into the steam pipe. The unbalanced column of mercury will, in this case, be partly balanced by a column of water of equal height. If h = the manometer reading in inches, the equivalent pressure difference in inches of mercury will be,

$$h' = \frac{13.6 - 1}{13.6} h = 0.926\,h$$

Substituting this expression in formula (7), we have, for steam,

$$W = 0.4681 f a \sqrt{0.926\,hs} = 0.4508 f a \sqrt{hs} \qquad (9)$$

To determine the values to be assigned to the coefficient f, the orifice O was arranged to discharge into a pipe leading into a tank of water mounted on scales, so that the rate of flow of the steam could be determined by condensing. The quality of the steam was determined by a throttling calorimeter taking a sample near the orifice.

TABLE 1. RESULTS OF TESTS WITH AIR

	Temperatures				Pressures								
	T_1		T_2		P_1, Lb. per Sq. In. Abs.	h, In. of Mercury	h, Lb. per Sq. In.	P_{12} Lb. per Sec.	$\frac{W}{k}$	$\frac{W}{f}$	k Col. 9 ÷ Col. 10	f Col. 9 ÷ Col. 11
No.	Deg. F.	Deg. Abs.	Deg. F.	Deg. Abs.					For. (4a)	For. (8)		
1	2	3	4	5	6	7	8	9	10	11	12	13
1	85	545	85	545	24.5	1.2	23.9	0.0242	0.0388	0.0406	0.624	0.597
2	88	548	88	548	34.5	1.72	33.7	0.0348	0.0549	0.0573	0.635	0.608
3	90	550	89	549	44.5	2.22	43.4	0.0449	0.0709	0.0740	0.634	0.607
4	93	553	92	552	54.5	2.8	53.1	0.0547	0.0878	0.0919	0.623	0.596
5	100	460	97	557	64.5	3.25	62.9	0.0646	0.1025	0.1069	0.630	0.602
6	104	564	103	563	74.5	3.81	72.6	0.0742	0.1185	0.1237	0.626	0.600
7	108	568	107	567	84.5	4.27	82.4	0.0837	0.1331	0.1390	0.629	0.602
8	114	574	113	573	87.5	4.48	85.3	0.0867	0.1380	0.1444	0.628	0.600
Averages of k and f											0.629	0.602

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TABLE 2. RESULTS OF TESTS WITH STEAM

Gage Pressure above Orifice, Lb. per Sq.In.	Quality of Steam, Per Cent.	Weight of Steam Condensed Lb.	Time in Seconds	Rate of Flow, Lb. per Sec.	Manometer Reading, In., = h	W ÷ f, from Formula 9	f = Column 5 ÷ Column 7
1	2	3	4	5	6	7	8
30	100	12.5	600	0.0208	1	0.0332	0.633
30	100	19.0	600	0.0317	2	0.0469	0.677
30	100	21.5	600	0.0342	3	0.0573	0.597
50	99.5	20.5	600	0.0342	2	0.0559	0.612
50	99.5	30.5	600	0.0509	4	0.0788	0.646
50	99.5	32.5	600	0.0542	5	0.0882	0.615
70	99.0	20	720	0.0278	1	0.0452	0.615
70	99.0	23	600	0.0383	2	0.0638	0.600
70	99.0	29.5	600	0.0491	3	0.0781	0.628
70	99.0	33.5	600	0.0558	4	0.0900	0.62
80	99.0	21	720	0.0292	1	0.0475	0.615
80	99.0	25.5	600	0.0425	2	0.0675	0.63
80	99.0	33.5	660	0.0508	3	0.0824	0.617
80	99.0	35	600	0.0583	4	0.0950	0.615
80	99.0	34	480	0.0709	6	0.1160	0.611
80	99.0	47.5	600	0.0791	7	0.1250	0.633
Average value of f							0.622

Editorials

The Engineering Society

In another column is a review of a paper by Ernest McCullough dealing with the causes that led to the organization of the newly formed American Association of Engineers. If the picture that he draws of the older societies as groups of smug individuals who have won their spurs and who spend their time and the resources of the societies vaunting one another's achievements and in mutual admiration, to the neglect or discomfiture of the younger aspirant for engineering honors, is a true picture and if this condition—if it exists—cannot be remedied, the younger men are justified in getting together an organization of their own.

But is it?

True, the existing societies of professional engineers are supposed to consist of members that have already become engineers. But the American Society of Mechanical Engineers, for instance, has a junior membership to which any graduate of an engineering school or anyone occupying a subordinate engineering position is eligible, with all of the privileges of the society except voting. The lower age limit for this grade is twenty-one years, but the society has also student branches, to which undergraduates of engineering schools are eligible. It is natural that the older men, who from long and active connection with the society and successful practice as engineers have earned their right to such recognition, should be elected to fill the leading offices, but a review of the Council will find it to consist upon the average of fairly young and active men. The papers are largely inspired by the Meetings Committee, with numerous subcommittees, specialized as to subjects, and are not open to the charge of being adulatory of the work of the members. As an encouragement to the younger men to prepare papers, Henry Hess, a member of the Council and of the Publication Committee, has offered prizes to the junior and student member producing the best paper each year.

An active service department is maintained. Members out of a position are invited to place their names, desires and qualifications on record, lists of engineers available are published regularly, and those in need of the services of an engineer are urged to apply to the society. The "Year Book" of the society is a standing directory of engineers and is often consulted by those desiring professional service.

The society is also, through its Committee on Public Relations, endeavoring to bring about a recognition of the engineer and his consultation and employment in public positions, administrative as well as executive, in the conduct of which a knowledge of engineering is desirable. It is also taking an active interest in questions of legislation affecting the status of the engineer. It has a special committee to consider and advise changes in the patent laws of the United States.

It is an association of engineers dealing in a broad way with mechanical engineering for the general good. Mr. McCullough's ideal seems to be an association of engineers banded together for the benefit of individual members.

Instead of dealing generally with the patent system and obtaining reforms that would benefit the whole profession, he proposes a patent lawyer employed by the association to get out patents for individual members. The getting of jobs for its members is one of the principal, instead of incidental, activities of the combination, and none of its members must employ an outsider so long as a member is unemployed. He would even maintain an association lawyer to collect their pay. Nothing is said yet about members underbidding each other for jobs, but this may come in under the professional ethical phase of the subject and lead to a uniform scale of charges.

While there may be some ground for lack of real warm blood and good fellowship in the recent reunions of the older societies, it is certain that they could not go so far as the proponents of the new movement propose in the directions discussed, and it is doubtful if engineering as a profession can be best advanced by an organization constituted along these lines.

Enter, the Heating Season

It must have been an operating engineer who first added emphasis to the expression—Life is just one thing after another. No sooner is there a brief respite from the torrid temperatures heaped upon the power plant by summer weather than the early frosts of fall arouse visions of combating the discomforts of winter. Heating apparatus that during the good old summertime would have been regarded as second only to the horrors of war must be limbered up for another repulse of grim old winter. If defects were not remedied before the beginning of the heating season, then the sooner the better, for the trouble and expense will be repaid to all concerned, with compound interest.

No matter how well an apparatus may have been designed, without a careful inspection there is no telling what may have happened during months of idleness to impair its operation. The entire system should be examined. When pressure is raised, a visit of inspection should be made to every radiator and coil to see that air cocks are adjusted for proper operating to insure against dead radiators. Examination should be made of the runs of the piping and fittings to see that the piping has not become deranged or pockets formed that will cause a water hammer which is not only annoying, but may rupture pipes, fitting and even radiators during the part of the heating season when service of the apparatus is in greatest demand.

To one who is in charge of a heating plant, a balky heating apparatus is a greater nuisance than a pounding engine and may prove to be not only a detriment to his peace of mind, but an injury to his reputation as an op-

erating engineer. He should insist that alterations or repairs necessary for putting the apparatus in good working order are made early and thoroughly. The cost may be met grudgingly by an owner, but a frown at the expenses is easier to confront than a season's complaints of inefficiency.

The Water-Power Conference

The latest effort of the interests that are attempting to get control of the water powers of the country is the holding of a conference at Portland, Oregon, at which a dozen of the Western states were represented. United States Senators Thomas J. Walsh of Montana, Chamberlain of Oregon and others upheld the efforts of the Federal Government to retain the rights of the people in these powers. Senator Reed Smoot of Utah, S. Z. Mitchell, president of the Electric Bond and Share Co., and others opposed such efforts. The Ferris Bill, the passage of which by the last Congress the water-power interests succeeded in blocking, was the direct object of attack.

The Ferris Bill simply provides that the individual or corporation that undertakes to develop the water powers shall do so at a fair profit, and if the Government wants to take them over after fifty years, it may do so by paying the owners a reasonable valuation, leaving them in the enjoyment of the fair profit which they may have made. The day of giving away valuable privileges in perpetuity or for half-century periods, leaving several generations open to extortion, is over. If private capital will not develop these powers at a fair return upon the investment, the people can and will. And they will be as good investments in their influence upon rate and price making as the Government's development of some of its coal and oil lands would have been a generation ago.

Height of Chimneys for Burning Anthracite

The natural draft of a chimney depends upon the height of the top above the fuel bed. In case a heat-reclaiming device, such as an economizer, is installed, the draft conditions become changed and either an extremely high chimney or mechanical draft is necessary. Under ordinary conditions the height of chimney necessary to produce a draft sufficient to draw the required supply of air through the fuel depends both upon the rate of combustion and upon the size of the coal burned.

Engineers have been puzzled as to why difficulty has been experienced in burning anthracite with short chimneys. This is because they take no account of the size being burned, undoubtedly assuming that a chimney is a chimney and that coal is coal. In practice it has been determined that when large, or steam, sizes of anthracite are burned and natural draft is used, a chimney should be not less than sixty feet in height, and if an economizer is installed eighty-five feet is the minimum height. When small sizes of anthracite are to be burned, the height of the chimney with natural draft becomes prohibitive and mechanical draft is utilized, which permits of a comparatively short chimney.

It is a surprising fact that a change from one fuel to another of lower grade makes it necessary to increase the height of a chimney. For instance, suppose a plant is burning pea coal at a maximum rate of twenty-five pounds per square foot of grate per hour, the height of the chimney to produce the necessary draft being about one hundred and seventy-five feet. For one reason or another it is desirable to burn number three buckwheat. It would be found upon trial that the same chimney would not produce the draft satisfactorily and to obtain it a chimney approximately three hundred and eighty-five feet would be required to get the same rate of combustion, and even then the steaming capacity would doubtless decrease on account of the lesser heat value of the fuel. Naturally, the proper height of chimney to obtain the same steaming capacity would be much greater, as for instance, those serving the higher buildings of our large cities. The cost of a self-contained chimney of such height would be prohibitive.

Remodeling a chimney is expensive, and to increase its height fifty per cent. would entail a cost about equal to that of building the original chimney. Furthermore, the cross-sectional area necessary to accommodate the greater volume of exhaust gases is of equal importance. Before an engineer decides to change the grade of coal to be burned in a boiler furnace, he should ascertain if the existing height of the chimney and its cross-sectional area are such as will produce the necessary draft and if it is of sufficient capacity to carry off the products of combustion.

Who Ought To Know Best?

The construction of a great development plant in the Niagara district has become an urgent necessity by the rapid growth of the cheap power system in Ontario. Sir Adam Beck and his colleagues on the commission are facing the end of their present sources of supply. The 100,000-hp. supply contracted for with the Ontario Power Co. at the Falls will soon be exhausted by the increasing demands of the municipalities, which even the big increase in the supply from new plants here and there in the province will not meet. With the advent of hydro-radial (or rural) car lines on an important scale, the present supply will fall far short, and when that time arrives the commission must be in a position to furnish practically unlimited power.—U. S. Consul Julius D. Dreher, Toronto, in *Commerce Reports*.

With all the advantages of governmental support and by the expenditure of public funds, the Niagara system of the Hydro-Electric Power Commission of Ontario has succeeded in disposing only of about fifty-thousand horsepower, and it is wholly improbable that any very large addition could be expected to be developed in Ontario for many years to come.—Reginald Pelham Bolton, in a letter to the *New York Times*.

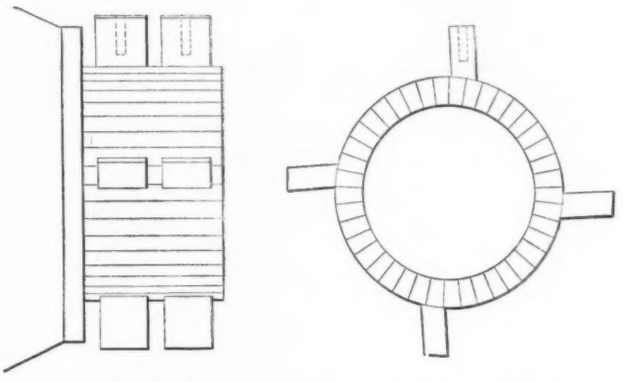
The truth is that there is relatively little power available with the present developments, as anyone will quickly find out if he tries to obtain a contract for a large block of power. Those of us who are interested in processes requiring large amounts of electrical energy would like to see a much greater power development.

It is possible to suffer gladly sentimentalists, or those who have developed a strong sense of the beauty of waste, or even others who have less worthy motives for opposing the use of the Niagara River; but it is difficult to be patient with the erroneous assertions of engineers who ought to know better.—Francis A. J. Fitzgerald, Niagara Falls, N. Y., in a rejoinder in the *New York Times*.

Correspondence

Self-Lubricating Brush Substitute

Some time ago the writer saw a substitute for a self-lubricating brush which, in addition to performing the desired function, was ingenious. As shown in the sketch, the top set of brushes were drilled radially to within about half an inch of the commutator, the hole being about one-quarter inch in diameter. Into this hole a plug of paraffin was inserted, and the heat developed in the brush was sufficient to slowly melt the paraffin and allow it to soak through the brush and lubricate the commutator. When



HOLE DRILLED IN BRUSH FOR PARAFFIN

the paraffin had all melted, another plug would be inserted.

The fact that the commutator had been running for several years without the least sparking or squeak and had acquired a beautiful dark-brown glasslike finish was evidence that the scheme was working out well.

P. Justus.

Cleveland, Ohio.

Cleaning Double-Pipe Condenser

I was interested in C. E. Anderson's "Experiences of a Refrigerating Troubleman," *Power,* Sept. 7, p. 330. I would like to know how the sand came to get over into the compressor from the condenser, passing through the risers, expansion valves and refrigerating coils and back to the machine.

I tried that way of cleaning once, but I used steam instead of air and had a double-pipe condenser four pipes high, making three return bends to overcome. I separated each bank, and after the pipe showed clean at the discharge end I washed the coils out with water at 100 lb. pressure and then blew them out with steam. We never had trouble with sand or any other grit afterward. Of course I would not undertake to clean a double-pipe condenser in this way without first separating each stand or bank of tubes, because there is a limit to the cleansing power of steam and water; but it seems to me that the evaporating coils would act like a trap in this case and separate and hold whatever sand or grit would remain in the condenser and pull over through the expansion valves, and that the cause of cylinder scoring must have been something more than that, or else the rate of flow through the evaporating coils was a great deal higher than I have ever experienced.

A. A. Blanchard.

Ringwood Manor, N. J.

Comparison of Chimney Sizes

Mr. Lathrop's article, Aug. 31, p. 299, is a step in the right direction, and similar information for other branches of power-station design would be appreciated. As regards chimneys, his system can be improved.

The item, boiler horsepower per square foot of chimney, by which comparisons are made, forms no true basis for comparison because the height is not considered and the actual area is used in place of the effective. For small differences in height and for large chimneys the deviation is small, but it cuts down the latitude of installations for comparison.

Kent holds that in any chimney, regardless of size, there is next to the shell a 2-in. annular stratum which is inactive, and therefore the diameter of the effective area differs from the actual diameter by 4 in. As this reduction is greater in proportion in small chimneys, if disregarded no comparison can be made unless the sizes are approximately alike.

From Kent's formula, $E = \frac{0.3\ Hp.}{\sqrt{H}}$, it is seen that the effective area E varies directly as the horsepower $Hp.$ and inversely as the square root of the height. If the height be disregarded, the horsepower per square foot of effective area of two chimneys cannot be compared unless the heights are nearly the same.

Using Mr. Lathrop's method, two chimneys cannot be compared unless they are alike in diameter and height; that is, practically the same chimney.

The Kent formula, transposed, is $3.33 = \frac{Hp.}{E\sqrt{H}}$ and a constant is obtained that is equal to the ratio of the horsepower to the product of the effective area and the square root of the height. Applying this to Nos. 1 and 5 in Mr. Lathrop's table, whose diameters and heights vary widely,

$$D_A = 21\ ft.;\ D_E = 20\ ft.\ 8\ in.;\ E = 336.5\ sq.ft.$$

$$K = \frac{15{,}600}{336.5\sqrt{250}} = \frac{15{,}600}{336.5 \times 15.81} = 2.94$$

$$D_A = 8\ ft.;\ D_E = 7\ ft.\ 8\ in.;\ E = 46.2\ sq.ft.$$

$$K = \frac{1{,}530}{46.2\sqrt{125}} = \frac{1{,}530}{46.2 \times 11.18} = 2.96$$

It is seen that they are equally proportioned, although in the table 45 and 31 boiler-horsepower per square foot

would lead one to infer that there is a considerable variation. Number 11, whose ratio is 4.33, is much too small, being not half as big as required, as would be indicated by 64 boiler-horsepower per square foot as compared with the value of 32 which Mr. Lathrop finds average practice.

L. W. Cutler.

Union Hill, N. J.

Economizers in Modern High-Pressure Power Plants

In *Power* for Sept. 14 there appears an article descriptive of the Connors Creek power plant of the Detroit Edison Co., by C. F. Hirshfeld. In this article it was stated that economizers were not installed because, as at present built, they were not considered a proper installation for the modern high-pressure power plant. This brings up a point which has no doubt agitated the minds of engineers in this country, as well as abroad.

From the statements in the article we would be led to believe that Mr. Hirshfeld does not consider cast iron a suitable material for economizer construction. If an economizer is not made of cast iron, the only other materials from which it can commercially be constructed are wrought iron and steel. In Europe, where high pressures have been prevalent for many years, the steel and wrought-iron economizers have been extensively experimented with, especially in Germany. However, they have never made real progress against the cast-iron economizer, because of the exceedingly short life which, according to my experience, does not average under the most favorable conditions more than three years. Cast-iron economizers have been successfully and widely used in Europe for pressures up to and exceeding that prevailing at the Connors Creek plant—namely, 225 lb.

The maintenance cost of these machines has invariably been less than that of either the steel or the wrought iron. In fact, it may be said that it has been proved, without the shadow of a doubt, that cast iron of the proper grade and texture is the only serviceable metal for economizer service, as the corrosive action of both the gases and the water soon causes the steel and wrought iron to give way.

Perhaps it is an error to assume that Mr. Hirshfeld objects to the use of cast iron in economizer construction. Possibly his objection to the economizer may be based on the belief that the present design is inadequate for high-pressure work. Against this argument I would call attention to the fact that cast-iron economizers have been designed and are being built in this country for working pressures up to 350 lb., which possess, throughout, a factor of safety, including the holding power of the tubes in the headers, of five. Of course the construction of these machines shows a very material change from the old, comparatively low-pressure machine, in the same way that the present high-pressure boiler does from its predecessor of some years ago. To the best of my knowledge, the highest-pressure economizers which have been designed and built in this country up to the present time are those which will be installed in the power plant of the West Penn Traction Co. at Connellsville, Penn. These have been built to operate under a working pressure in the economizer of 350 lb.

The function of an economizer is of course quite different from that of a boiler. It is difficult to see what objection there can be to using cast iron for this purpose. In the event of a fracture in the economizer, the only damage that can occur is that which may be caused by the escape of hot water. It is always possible, of course, that this may occur in a cast-iron economizer, but it is likely to occur in the steel or wrought-iron type in a much shorter time, when corrosion has weakened the tubes. Therefore it seems that when all points are taken into consideration, the cast-iron economizer as now built is not only a proper apparatus for the modern high-pressure plant, but is the only type which can be employed with satisfaction, from the viewpoint of reliability and overall commercial economy.

George C. Usher,
Green Fuel Economizer Co.

New York City.

Direct-Reading Barometer

In filling a glass tube with mercury as used in the direct-reading barometer described by Mr. Sampson in the issue of Aug. 3, p. 164, the process, concerning which J. E. Pelton asks on p. 423, Sept. 21, consists of "boiling out" the air and moisture. Put in about an inch of mercury, then expose the tube to the heat of an alcohol lamp, which may be made by putting wicking into the neck of a small bottle containing alcohol. Heat the tube uniformly and gradually, to avoid breaking it, until the mercury does not "boil" as it did at first and all of the air is expelled. Add more mercury and repeat the boiling, taking care not to allow air to mix with or get beyond the mercury already treated.

There is some difficulty with a tube of the shape described, but if a considerable length of tube is left on the open end while filling (to be cut off afterward) and it is bent upward when the tube lies on its side, the mercury may be poured in and heated without serious difficulty. If too much mercury is put in at a time, its weight will cause considerable pressure on the air bubbles and prevent them from escaping, the pressure exerted by a column of mercury 1 in. high being nearly ½ lb. The work becomes fascinating when once the "trick" is learned.

Thomas Riggles.

Washington, D. C.

Hanger Brackets for Horizontal Return-Tubular Boilers

I have noticed the diagram of Prof. A. A. Adler's boiler bracket, published in *Power,* July 27, and question why he showed the suspender rod standing off at an angle away from the boiler shell. If he had shown it at an angle over the shell I should have agreed with him.

By referring to my paper, "The Hanging and Setting of the Horizontal Fire-Tube Boiler," *Proceedings* of the American Society of Mechanical Engineers, Vol. XIX, 1898, it will be seen in the illustration showing my three-point and equalizer suspension that the suspending links straddle over the shell, rather than incline, as Professor Adler's diagram would indicate, or hang vertically, as Mr. Dean shows in his diagram in *Power,* Aug. 31, p. 309.

I recalled to mind Mr. Dean's bracket when looking at Professor Adler's diagram, for I have seen it on some of Mr. Dean's large boilers, and have been impressed with its substantiality, and think it would not be improved by providing an inside strap, as suggested by Professor Adler.

Up to the present I have seen nothing to convince me that inclining the suspension links over the boiler shell some twenty-five or thirty degrees is not preferable to hanging them vertically. Two things at least are gained thereby—bringing the strain on the bracket more nearly tangent to the shell and enabling the use of a shorter equalizer shackle. This, however, contemplates link-and-pin shackle construction rather than eye-bar and nut construction. Yet I know of one large plant where the inclined eye-bar and nut construction is used with the Woolson three-point and equalizer system, but the plates for taking the suspender nuts are specially constructed for the purpose of straddling the shell.

Orosco C. Woolson.

New York City.

Experiences of Refrigerating Troubleman

Mr. Anderson's article in the Sept. 7 issue of *Power*, especially the experience with the defective suction gage and running the compressor as a liquid pump, was indeed interesting.

Frankly, it seems to me that using the compressor as a pump is impossible, but peculiar things sometimes happen and this may be one of them. Operating men, erecting engineers, designers and manufacturers agree that the presence of any large quantity of liquid in the suction gas entering the compressor is synonymous with a bad accident, and to meet this condition many provide false heads in the compressor, others use extra clearance.

In my tenderfoot days as a refrigerating engineer, I had to start a machine that was working on a brine cooler. About half an hour after starting I found the brine temperature had gone up instead of down. I looked several times to convince myself that I was not "seeing things." Going back to the machine, I found that it was running warm, that the head pressure was much lower than normal and that the back pressure was 25 in. of vacuum. Of course I began to hunt for trouble, and the expansion valves received my first attention. These were dead to all appearances, as there was no sound of anything going through them and the frost was all gone from the low-pressure side of the valves. I opened them wide and shut them again several times, trying to detect some sound of liquid or gas passing through, but failed. I examined the liquid line from the condenser to the expansion valves and found all the valves open and everything as it should be.

Suddenly I remembered that I had not opened the suction valve on the cooler. At once I made a dash for the valve. It worked freely and I gave it a spin that opened it several turns. The next moment bedlam broke loose. There was a medley of pounds, knocks, grunts and groans at the compressor, the building jarred, a shower of liquid ammonia shot out of the relief valves and down along the piston rods, and the machine nearly stopped.

I closed the valve again, before the machine stopped, and the latter gradually came up to speed. The oiler and everybody else in the engine room had gone out of the door or through the windows. I shut the expansion and the suction valves on the machines and opened the brine-cooler suction valve wide. Then I "camped" right by the machine suction valve, with one hand on the discharge line, and gradually opened the suction valve. It was about half an hour before I could open that suction valve wide. Whenever I found the discharge line getting cold and the valves working too quietly I would shut off the suction valve until the discharge line warmed again and the valves sounded normal, when I would open it. Any inclinations I might have had to make a liquid pump out of an ammonia compressor died right there.

I have had the same thing happen twice since, while pumping out the expansion coils after having pumped out the rest of the system into the coils. The results, while not as severe as the one just related, were sufficient to scare everybody out of the engine room. The machines pounded and the pipe jumped and rattled.

A friend of mine in a large plant where they have considerable trouble with liquid coming back in slugs with the suction gas tells me they have substantially the same indications. The engine room sounds like a battery of artillery in action, and the liquid blows out of the relief valves. The heads have been knocked out twice.

From these experiences and incidents related to me by others, I am not convinced that Mr. Anderson's machine pumped liquid. If it did, it would have made enough disturbance to indicate to a man of Mr. Anderson's experience what the trouble was without further investigation.

Take an example. The cylinder dimensions of a certain 40-ton machine that I have in mind and that is as large as one would expect to find in an installation of the kind described by Mr. Anderson, are 11x24 in. The machine is double-acting and runs at about 60 r.p.m. The displacement per minute would be

$$11^2 \times 0.7854 \times 24 \times 2 \times 60 = 273{,}696.192 \textit{ cu.in.}$$

The suction line is 3 in., the discharge 2½ in. and the liquid line from the receiver to the expansion valves 1 in. These proportions are fairly representative of all compression refrigerating systems. The area of 1-in. extra-heavy pipe is 0.719 sq.in. To pass the quantity of liquid handled by the compressor per minute the velocity of the liquid in the line would have to be

$$\frac{273{,}696.192}{0.719 \times 12} = 31{,}721.9 \textit{ ft. per min.}$$

which would be "some" velocity.

Mr. Anderson states that the liquid level dropped regularly with every stroke of the compressor and takes this as proof that the compressor was pumping liquid. If the liquid was passing through the line at the rate estimated there would be no effect in the receiver; the flow would have to be uniform to maintain this rate, and if the flow was pulsating the velocity would have to be greatly in excess of this at certain moments. To accelerate the column of liquid to this velocity and stop it again every revolution would require considerable pressure. The expansion coils would act as an accumulator and take the pulsations of the compressor on one end, and the condenser would care for the other,

consequently there could be no indication of pulsation in the receiver glass. All the pressure he had was that due to a condenser temperature of 86 deg. F., corresponding to a pressure of 156 lb. If the pressure rose above this the gas would condense until the condenser was full of liquid and the pressure was built up high enough to force the liquid through the liquid line. In this case the receiver would be full of liquid, and I would not care to be in the vicinity of the condenser. The suction pressure was 60 lb. This would mean a pressure difference of 96 lb., which would not begin to maintain the required velocity in the liquid line. For comparison, imagine a water pump of the same dimensions and speed as the compressor, with a 1-in. discharge line, and consider what the pressure would be to take care of the discharge from the pump.

As it must have been impossible for the liquid line to pass sufficient liquid to keep the compressor supplied, the liquid must have come back in slugs, and if it did the machine must have made much noise. The absence of noise and vibration makes me doubt that the machine was pumping liquid.

THOMAS G. THURSTON.

Chicago, Ill.

Some Useful Suggestions for Engineers

In drilling very hard steel, use turpentine instead of oil and you will be surprised at the ease with which it can be done.

To drill holes in glass, use a mixture of equal parts of turpentine and camphor and when the drill comes through feed very slowly. The glass should be laid on some smooth surface for drilling.

To loosen a rusted screw or stud bolt, apply vinegar, or heat with a piece of hot iron; when cool it will come out easily.

Working brass or copper causes it to become hard and brittle. To anneal it, heat to a dark red and plunge it into cold water. If heated too hot, however, it is liable to crumble.

Babbitt metal should be heated enough to char a soft-pine stick used to stir it—overheating ruins it. The bearing it is to be run in should be warmed up with a blow-torch or by laying a hot iron on it, to insure an even run of the metal. Remove all moisture from the bearing before pouring, as the hot metal, if it comes in contact with water, will cause an explosion.

C. M. KNOWLAND.

Louisville, Ky.

Measuring the Flow of Water for Pump Testing

Having read a number of articles in *Power* on the measurement of the flow of water for pump testing, etc., I believe the following will be of value to readers who are engaged or interested in work where such measurements are necessary or desired:

The measuring of pump discharges over weirs, while accurate if carefully conducted, requires a cumbersome and often impracticable "set-up," and at the best can be used for tests of short duration only, under conditions that may be different from those under which the pump normally operates. A venturi throat and a manometer for this purpose make a more convenient apparatus, and tests are always made under actual working conditions, but the diameter of the throat must bear a proper relation to the pipe diameter and the velocity of the water; otherwise, the discharge pipe will be unduly restricted or measurements will not be of sufficient accuracy, accordingly as the throat is too small or too large. This is a drawback where there is considerable fluctuation in the flow or where the rate is apt to be changed after the throat is installed. As the throat is not portable, its cost may be considered high where only occasional tests are necessary, especially in plants having a number of pumps. The cost of a recording venturi meter makes continuous records in many cases prohibitive, even where such records would be of considerable value.

A means of measurement for pump work that could be used conveniently for tests or continuous records, be readily transferred from one pipe to another and give accurate results would fill badly felt needs in many steam plants.

There has recently been placed on the market a recorder which, used in connection with a pitot-tube rod, meets these three requirements, besides embodying a number of other features.

This recorder is the simplest and most accurate for its class of work. Its principle of operation is the measurement of the level of a mercury column in a simple U-tube manometer, which level is maintained by the differential pressure produced by the flow to be measured. The differential pressure merely balances the mercury column and has no work to perform whatever, which allows responses to small changes in flow. The mercury level is measured and recorded on a chart by means of an electric circuit and a pen movement operated by a small water motor. The calibration of this instrument is determined by the specific gravity of the mercury, which is fixed. The recorder is portable and weighs but six pounds, not including three ordinary dry cells, and may be connected to the pitot-tube rod by rubber tubing. This makes a handy kit for any engineer.

WM. THEO. VAN DOREN.

Washington, D. C.

Welding Header Saves Time, Material and Money

One of the cast-iron headers of our boilers cracked on both sides from the cap end within 2 in. of the tube end. A welder was called, and he chipped off enough cast iron around the header above the cap to shrink on a ½x¾-in. wrought-iron ring. Then he chipped a groove ⅛ in. deep on each side of the crack, put on the electric welding machine, and inside of three-quarters of an hour the work was done. The whole job required three hours. The boiler inspector put on 225 lb. water pressure, and there was no sign of any leak whatever.

This boiler is rated at 250 hp., carries 125 lb. of steam, and has been working eight weeks with no sign of distress at the weld. This work saved nine new tubes, several days for boilermakers, and one new header—in all about $125. It cost $15.

M. HELMSTRIET.

Trenton, N. J.

Inquiries of General Interest

Assistance of Friction Between Plates of Boiler Joints—In estimating the strength of riveted joints, what allowance is made for the assistance of friction between the plates?

D. B. A.

While friction between the plates undoubtedly enhances the holding power of riveted joints, its value cannot be depended upon as a basis for calculation. Tests of joints have shown that there is variation in the holding power due to friction, depending on the condition of the plates, and when the plates were new and clean, considerable slip was discernable long before the working load of the joint was reached. The assistance of frictional resistance between the plates of a boiler joint may therefore be disregarded, both on account of its uncertainty and relatively low value.

Estimating Length of Belt—What formula can be used practically for estimating the length required for an open belt, knowing the sizes of the pulleys and the distances between their centers?

J. J. G

Taking all dimensions in feet or in inches, where
D = Distance between centers of pulleys;
R = Radius of the larger pulley;
r = Radius of the smaller pulley;
x = Required length of belt;
then a close approximation to the true length is given by the formula,

$$x = 2D + 3.1416 (R + r) + \frac{(R - r)^2}{D}$$

Horsepower Constant—What is the horsepower constant of a 22x48-in. engine running 70 r.p.m., and what horsepower would be developed for 37 lb. m.e.p.?

J. B. R.

The area of the piston would be $22 \times 22 \times 0.7854 = 380.13$ sq.in., and the piston speed would be $\frac{48 \times 2 \times 70}{12} = 560$ ft. per min. As the horsepower constant is the number of horsepower that would be developed by a mean effective pressure of 1 lb., then

$$\text{Hp. constant} = \frac{1 \times 380.13 \times 560}{33{,}000} = 6.45 \text{ hp. per lb. m.e.p.,}$$

and for 37 lb. m.e.p. the power developed would be

$$6.45 \times 37 = 238.65 \text{ i.hp.}$$

Transmitting Capacity of Leather Belts—What is the rule for computing the transmitting capacity of leather belts?

C. P. B.

The transmitting capacity of a belt depends on its strength, tension, velocity and frictional adhesion to the pulleys. As these conditions are variable, no rule for computing the exact transmitting capacity can be given. A good rule for estimating the approximate transmitting capacity of leather belts, as employed in average practice, when used on iron pulleys 24 to 60 in. dia., is to allow that 1 hp. may be transmitted per inch width of single leather belt for a velocity of 785 ft. per min., which corresponds to the peripheral speed of a 30-in. dia. pulley making 100 r.p.m. Therefore, to find the approximate capacity per inch of width of single leather belt, multiply the diameter in inches of one of the pulleys by its r.p.m. and divide the product by 3,000, and for double belts multiply the quotient by 2.

Drawing Vacuum Line on Indicator Diagram—How is the true vacuum line located and drawn on a steam-engine indicator diagram?

L. W. F.

In taking a diagram the atmospheric line, or line of atmospheric pressure struck on the diagram before disconnecting the drum motion, should be taken as a reference or base line, and after removing the card from the paper drum of the indicator the line of absolute zero pressure, or true vacuum line, is to be drawn on the diagram below the atmospheric line and parallel to it at a distance which by the scale of the diagram would represent the pressure of the atmosphere. At sea level the distance in inches would equal 14.7 divided by the scale of the diagram. As the pressure of the atmosphere in pounds per sq.in. is 0.491 multiplied by the height of the barometer in inches, then for diagrams taken at places of considerable elevation above sea level, the true vacuum line should be located accordingly; that is, at a distance in inches below the atmospheric line equal to 0.491 multiplied by the height of the barometer in inches, divided by the scale of the diagram.

Computation of Brake Power—In making a Prony-brake test of a motor the speed of the brake wheel was 460 r.p.m., the horizontal length of brake arm was 52 in., and the net weight balanced was 47 lb. What number of brake horsepower was developed?

F. R.

The power developed is given by the formula,

$$P = \frac{L \times 2\pi \times N \times W}{33{,}000},$$

in which
P = Number of actual or brake-horsepower;
L = Length of brake arm in feet, which, when a balancing weight is used, would be the horizontal distance from the center of the brake wheel to the point of suspension of the weight;
$2\pi = 2 \times 3.1416$;
N = R.p.m. of brake wheel;
W = Net weight balanced, in pounds.
By substituting the values given the formula becomes

$$P = \frac{(52 \div 12) \times (2 \times 3.1416) \times 460 \times 47}{33{,}000} = 17.83 \text{ hp.}$$

Economy of Returning Condensate to Boiler—In a steam-heating apparatus supplied with steam at 10 lb. boiler pressure, what percentage of fuel would be saved if the return water, at present discharged by traps at 200 deg. F., is returned to the boiler by gravity at that temperature, in place of using fresh feed water at 55 deg. F.?

W. B. A.

The heat contained in a pound (weight) of steam at a boiler pressure of 10 lb. per sq.in., or practically 25 lb. per sq.in. absolute, is 1,160.4 B.t.u. above 32 deg. F., and with feed water at 55 deg. F. each pound (weight) of feed water for conversion into steam requires

$$1{,}160.4 - (55 - 32) = 1{,}137.4 \text{ B.t.u.}$$

By returning the condensate to the boiler at a temperature of 200 deg. F. each pound of water, for reconversion into steam, would require

$$1{,}160.4 - (200 - 32) = 992.4 \text{ B.t.u.,}$$

and therefore without taking into account any waste of steam by the traps, the saving would be

$$\frac{(1{,}137.4 - 992.4) \times 100}{1{,}137.4} = 12.74 \text{ per cent.}$$

Evaporative Performance of Boiler—What would be the performance of a boiler expressed in boiler horsepower if 44,229 lb. of feed water at 222 deg. F. were evaporated in 9 hr. into dry saturated steam at 100 lb. gage pressure?

P. C.

A pound (weight) of dry saturated steam at 100 lb. gage, or 100 + 14.7 (practically 115) lb. absolute, contains 1,188.8 B.t.u. above 32 deg. F., and with the feed water at 222 deg. F., or 222 — 32 = 190 deg. F. above 32 deg. F., each pound of feed water converted into steam would require 1,188.8 — 190 = 998.8 B.t.u.

Evaporation of a pound of feed water from and at 212 deg. F. requires 970.4 B.t.u., and therefore the factor for equivalent evaporation from and at 212 deg. F. would be $998.8 \div 970.4 = 1.029$.

A boiler-horsepower is usually as equivalent to the evaporation of 34½ lb. of water per hour from and at 212 deg. F., and on that basis, evaporation of 44,220 lb. of water in 9 hr. from a feed-water temperature of 220 deg. F. into dry-saturated steam at 100 lb. gage pressure would be an evaporative performance of

$$\frac{44{,}220 \times 1.029}{9 \times 34.5} = 146.5 \text{ boiler hp.}$$

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

The Diesel Engine in America

By Max Rotter*

SYNOPSIS—A résumé of present American practice as regards details of design, from a paper presented at the International Engineering Congress.

"Ignition by compression," so generally and superficially accepted as the fundamental principle underlying Dr. Diesel's invention, was, as a matter of fact, merely a natural corollary, and was not even claimed by him as his original conception, although typical of the engines that bear his name and successfully employed in them alone. Dr. Diesel's great aim was a closer realization of the theoretical efficiency of the Carnot cycle than attainable by steam engines or internal-combustion engines of the ordinary types. And although his aspirations were crowned with only partial success, it is scarcely to be doubted that they created a heat engine that has the highest efficiency that will ever be attained with fuel.

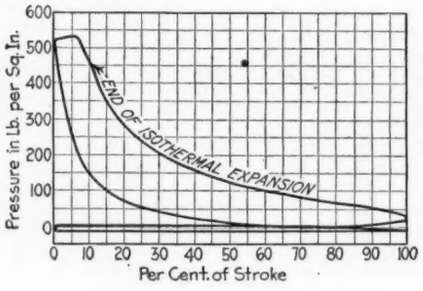


FIG. 1. DIAGRAM FROM FOUR-STROKE-CYCLE DIESEL ENGINE

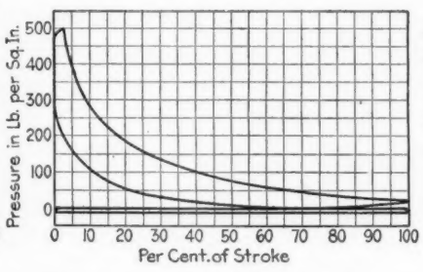


FIG. 2. DIAGRAM FROM FOUR-STROKE-CYCLE SEMI-DIESEL ENGINE

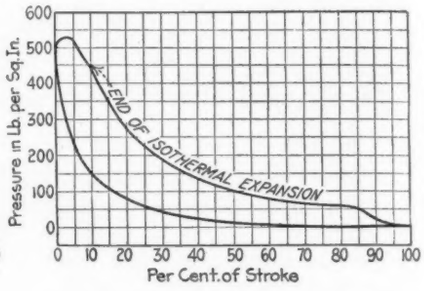


FIG. 3. DIAGRAM FROM TWO-STROKE-CYCLE DIESEL ENGINE

Carnot's law, as applying to heat engines, is well understood—the higher the initial temperature and the lower the terminal temperature, or the higher the initial compression pressure and the lower the terminal pressure, the higher will be the theoretical thermal efficiency. Dr. Diesel demonstrated that, although the theoretical and thermal efficiency increased slightly beyond this point, the highest mechanical efficiency was attained with a compression pressure of 30 atmospheres and a compression temperature of 500 deg. C. and, balancing these advantages against one another, that the highest actual efficiency and the greatest useful power development per unit of cylinder volume would be obtained by compressing the air to a pressure of between 30 and 40 atmospheres and a temperature between 500 and 600 deg. C.; and introducing the fuel in such manner as to obtain combustion at constant pressure with a maximum combustion temperature between 1,600 and 1,800 deg. C. On either side of these limits the actual efficiency of the engine diminished. It is evident that the stated compression temperature is "far in excess of that required" solely for the ignition of any carbonaceous substance that would ordinarily be used as fuel; also that, to avoid ignition during the progress of the compression, the fuel must not enter the cylinder until after the full compression has been attained.

In 1894 the first successful experimental engine operating upon these principles was completed by Dr. Diesel. In 1897 Adolphus Busch, of St. Louis, purchased outright the sole rights to all Dr. Diesel's existing and future United States patents and introduced the Diesel engine into this country under the sponsorship of the late Col. E. D. Meier.

The first Diesel engine built in the United States was completed in 1898. Since then these engines have been installed in municipal and commercial central power stations, in the most diversified industrial plants, and as stand-bys for water powers, in capacities up to 1,000 hp. In Europe stationary Diesel engines have been installed in units up to 4,000 hp., but the relatively lower prices of fuel in the United States tend to retard a similar development here.

Following in the wake of the Diesel, or high-compression constant-pressure oil engine, has come the so-called semi-Diesel, or low-compression oil engine. The distinguishing characteristics of the two types may be briefly stated as follows:

In the Diesel the entire cylinder volume of pure air is compressed to the maximum pressure of about 35 atmospheres and the corresponding temperature of about 500 deg. C., the fuel is introduced at or about the completion of this compression, and is gasified and ignited by the heat of compression; the combustion taking place without any material increase in pressure, but with a considerable increase in temperature, during 8 to 12 per cent. of the piston stroke, and continuing during a subsequent period of isothermal expansion.

In the semi-Diesel engine the entire cylinder volume of pure air is compressed to about half the compression pressure usual in the Diesel; a small portion of this air being contained in an auxiliary chamber that is in open communication with the interior of the cylinder and that has been heated to a high temperature (by external means prior to starting, or by the heat of the previous combustion while running), the temperature resulting from the mechanical compression being, therefore, considerably higher in this chamber than in the main portion of the cylinder. The fuel is introduced at or about the completion of this compression, either directly and entirely into this auxiliary chamber or through the cylinder and partially into the chamber, and is gasified and ignited by the heat of compression of the air in the chamber, the combustion taking place suddenly and with a greater increase in pressure than in the Diesel and being followed by a more rapid drop.

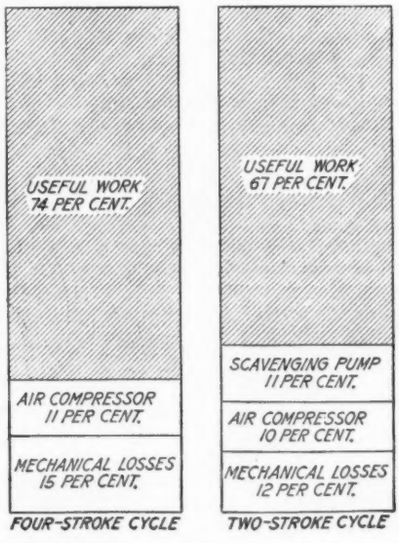

USEFUL WORK 74 PER CENT.
AIR COMPRESSOR 11 PER CENT.
MECHANICAL LOSSES 15 PER CENT.
FOUR-STROKE CYCLE
USEFUL WORK 67 PER CENT.
SCAVENGING PUMP 11 PER CENT.
AIR COMPRESSOR 10 PER CENT.
MECHANICAL LOSSES 12 PER CENT.
TWO-STROKE CYCLE

FIG. 4. HEAT DISTRIBUTION IN TWO- AND FOUR-STROKE-CYCLE ENGINES

In engines of both types the maximum ignition pressure is about the same, but the combustion temperature at the commencement of the adiabatic expansion is higher in the Diesel. Figs. 1 and 2 show, respectively, typical indicator diagrams of a Diesel and a semi-Diesel engine.

*Chief engineer, Busch-Sulzer Bros. Diesel Engine Co., St. Louis, Mo.

The two-stroke cycle, as well as the four-stroke cycle of operation, is employed in Diesel engines. The lower efficiency of the two-stroke cycle is due primarily to the power consumed by the scavenging pump, practically none of which is recovered in the working cylinder. This is partly offset by the reduced mechanical losses due to lighter moving parts. The drop of pressure at the release, when the exhaust port

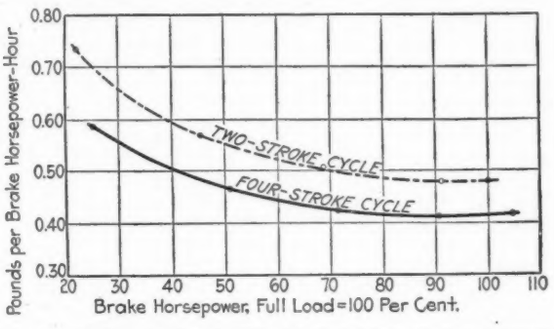


FIG. 5. CONSUMPTION CURVES FROM SNOW ENGINE

of the two-stroke-cycle engine is opened, is partially counterbalanced by the "bottom-loop" negative work of the four-stroke cycle.

Fig. 3 shows a typical diagram of a two-stroke-cycle Diesel engine and may be compared with Fig. 1, which is that of a four-stroke-cycle engine. Fig. 4 illustrates the proportional subdivision of the indicated power developed by four-stroke-cycle and two-stroke-cycle Diesel engines.

The curves shown in Fig. 5 compare the fuel consumption of four- and two-stroke-cycle Diesel engines built by the same American manufacturer.

The older designs of two-stroke-cycle engines, which were provided with cam-operated scavenging and exhaust valves, were run at speeds considerably below those which are usual in the equivalent four-stroke-cycle machines, because the camshafts of the former revolve at the same speed as their crankshafts, whereas those of the latter revolve at but half the speed. In later designs this limitation has been practically overcome by the substitution of scavenging and exhaust ports in the cylinder wall, controlled by the piston, in place of the heavy valves. This construction, although familiar in gas-engine practice, was adopted hesitatingly for Diesel engines, on account of their somewhat high exhaust temperatures, the supposed difficulty of constructing suitable cylinders, and the inefficient scavenging resulting from the fact that the scavenging ports had to be uncovered after the exhaust ports were open, and therefore re-covered before the exhaust ports were closed.

In Fig. 6 is illustrated the construction of a modern two-stroke-cycle Diesel-engine cylinder provided with a recently patented arrangement of scavenging and exhaust ports. The exhaust ports are controlled by the piston, as are also the scavenging ports in the lower tier; while the scavenging ports of the upper tier are under the supplemental control of a timed, mechanically-operated valve. The lower tier and the mechanical valve open only after the exhaust ports have been uncovered long enough for the pressure in the cylinder to have fallen below the scavenging air pressure; the mechanical valve remains open after the exhaust ports have been closed. This arrangement not only prevents the dangerous blowing back of hot gases into the scavenging air passages, but also insures more thorough scavenging and the building up of a slight excess pressure in the pure air in the cylinder at the commencement of the compression stroke, thus enhancing its volumetric efficiency and power capacity.

Stationary Diesel engines may be roughly divided into slow-speed and medium-speed machines. High-speed engines of this type are confined to special purposes, such as the propulsion of submarine vessels. Without material variation in piston velocities, the speeds of both classes of stationary engines have been, more or less, selected to conform to the speeds of standard engine-type electric generators. The higher rotative speeds that are becoming general in Europe have, up to the present, not found favor with American builder, despite the fact that they appear to be entirely successful. The following table compares the speeds of well-known European and American Diesel engines of about 500 hp.

	European	American
R.p.m.	240	150-200
Piston speed	4.15 m. per sec.	3.8-4.15 m. per sec.
Piston speed	815 ft. per min.	740-815 ft. per min.
Ratio, diameter to stroke	1:1.13	1:1.34-1:1.28

HORIZONTAL VS. VERTICAL ENGINES

Within these limits there does not appear to be any appreciable difference in efficiency, reliability or wear in engines of equally good design and construction.

In Europe there has been a very general adherence to the vertical arrangement of Diesel engines, and of the few builders of horizontal machines the majority build vertical engines also. In America both styles have their champions, but at the present time the greater number appears to be following the lead of Europe.

There are comparatively few double-acting engines of the Diesel type in operation in Europe and considerably fewer in America. Practically all of these are horizontal machines. It may be reasonably asserted that there is not yet available a sufficiently extensive practical experience with this style to warrant the assurance of success in everyday service; and that, in spite of the many advantages which such an engine would possess, especially in large units, its development still lies well in the future.

Vertical Diesel engines are being built both with "A" frames and with inclosed crank cases. Coincidently with the tendency toward higher speeds, there has developed in Europe an increasing inclination toward the inclosed crank case; and Sulzer Bros., of Switzerland, recently exhibited in Berne a Diesel engine of this construction, of 1,000 b.-hp. rated capacity. The inclosed crank case for Diesel engines was adopted in America long before it received any consideration in Europe, and the original American builders still adhere to this style of frame for engines of small and medium capacities.

Practically all Diesel engine cylinders are now built up of a liner, or inner barrel; a jacket, or outer cylinder, and a cylinder head. The space between the liner and the jacket forms the water jacket. The purpose of this construction is less that of facilitating the renewal of the inner barrel should it become worn and of permitting its free axial expansion, than to enable the use of the most suitable iron to withstand the temperatures to which the cylinder is subjected, without the manufacturing risks involved in casting.

The admission and exhaust valves, which are exposed to the high combustion temperatures and to the corrosive action of the fuel, most of which contains sulphur, are now generally made up of a head of hard cast iron, with a stem of forged steel. In this country Diesel engines are not yet being built in sizes that would make the water-cooling of the exhaust valves either necessary or convenient, but in the medium sizes the exhaust valve-stems generally work in water-cooled guides.

Few of the fuel oils in ordinary use are of such character that perfect combustion can always be attained under all

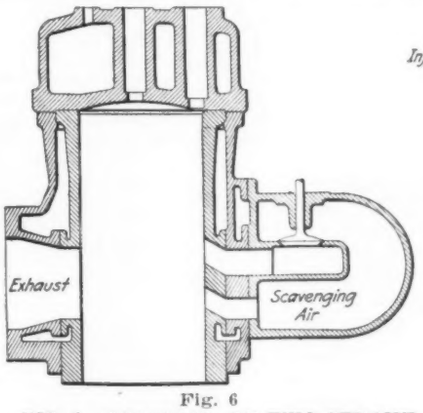


Fig. 6

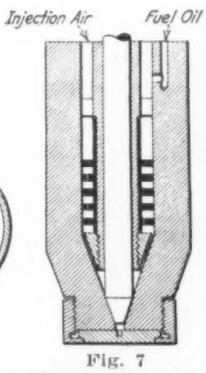


Fig. 7

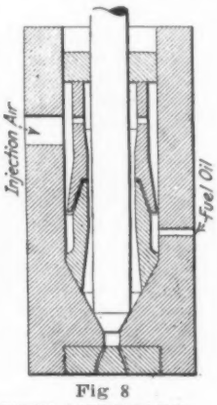


Fig 8

FIG. 6. CYLINDER OF TWO-STROKE-CYCLE ENGINE WITH AUXILIARY CAVENGING PORTS. FIG. 7. COMMON TYPE OF CLOSED FUEL NOZZLE. FIG. 8. HESSELMANN FUEL NOZZLE

conditions of load; it is therefore desirable that at least the exhaust valve, which is the most prone to fouling, may be dismantled with the greatest promptness and ease and with the least disturbance of adjustments.

More attention has been paid to the correct construction of the fuel atomizers than to any other single consideration, and with good reason. The experiments carried out on the

first Diesel engine proved that the atomizing of the fuel and its introduction into the cylinder could best be performed by means of compressed air. The elements employed consist of an atomizer, an injection valve and a nozzle. These may be arranged to form the "closed" nozzle as originally developed by Diesel or the "open" nozzle as developed by Lietzenmayer. In the former the injection valve is placed between the air and fuel passages entering the atomizer and the nozzle inlet to the working cylinder, the valve thus separating both air and fuel from the cylinder until the time of injection. In the latter the injection valve is placed between the air passage entering the atomizer and the fuel inlet to the atomizer.

The "closed" nozzle construction shown in Fig. 7 is that which has attained the most widespread use. The atomizing elements consist of a series of finely perforated plates, the holes in the alternate plates being offset with reference to each other; followed by a slotted cone leading to the injection valve and to the nozzle plate at the entrance to the cylinder. Prior to the moment of injection the requisite quantity of fuel oil for the next working stroke is delivered above the perforated plates and distributes itself over these, the interior of the atomizer being in open communication with the compressed air. When the valve is lifted from its seat the air flows in a rapid stream over the plates and through the perforations, carrying the fuel with it and tearing it into fine globules. In its passage through the nozzle plate, after leaving the slotted cone, the mixture of air and oil atoms is deflected into a flat "umbrella," spreading over the surface of the piston.

The atomizer illustrated in Fig. 8 is also of the "closed" type and is the invention of Mr. Hesselmann, of the Swedish Diesel Engine Co. The typical feature of this is the siphonic arrangement of the passage in which the fuel lies between the time of its entrance into the atomizer and the opening of the injection valve, the atomizing taking place at the inner upper edge of the siphon passage.

The use of the "open" nozzle, as illustrated in Fig. 9, is confined, in America, to horizontal engines. In this the fuel is delivered by the fuel pump into a passage which, through a nozzle, is at all times in open communication with the cylinder. The compressed injection air is closed off from this passage by the injection valve. When this valve is lifted from its seat the stream of air scours over the surface of the accumulated fuel and atomizes it with an action similar to that of a file upon a metal surface. The final atomizing and spreading is performed in the passage through the nozzle.

As the load decreases and the quantity of fuel injected into the cylinder for each working stroke diminishes, the too rapid injection of the fuel results in a more or less explosive

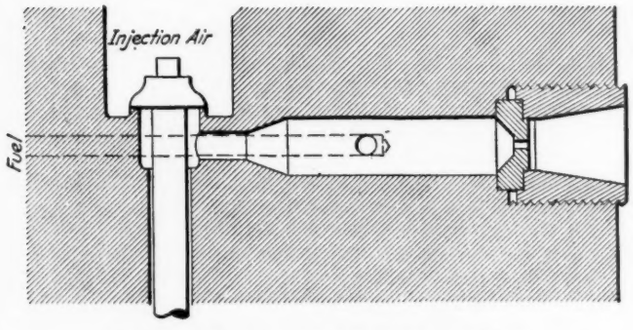


FIG. 9. OPEN TYPE OF FUEL NOZZLE

ignition. To avoid this it becomes necessary to reduce the pressure of the injection air; that is, to slow down the injection velocity by reducing the pressure difference between the injection air and the air compressed in the working cylinder. In the cases of the "closed" nozzle this is accomplished automatically, to a limited degree; there being less fuel in the atomizer to retard the flow of air, more air is injected and if the free-air capacity of the compressor remains constant, the injection pressure falls to correspond to this greater delivery volume. But this self-adjustment is insufficient to accomplish the purpose and has the additional disadvantage that, in spite of the more explosive ignition, the combustion is imperfect, because of the cooling effect of the excess air following the fuel into the cylinder, and it is necessary either to blow off a portion of the compressed air or to regulate the volume handled by the compressor. The latter is the general practice and is effected by throttling the suction of the compressor. This is usually done by hand, but some engines are provided with mechanical means operated by the governor.

All engines of the Diesel type are started by compressed air. To avoid excessive use of air and to simplify the mechanism, it is usual to provide only one or two of the cylinders of a multicylinder engine with starting valves and to relieve the compression in the other cylinders until the engine has attained sufficient speed to effect this compression without risk of stopping. In small and medium-sized engines the relief of compression is generally accomplished by holding the exhaust valve partially open, which was formerly somewhat crudely done by slipping a yoke over the exhaust-valve lever; but now it is usual to mount the lever hubs on eccentric sleeves operated by hand levers, the arrangement

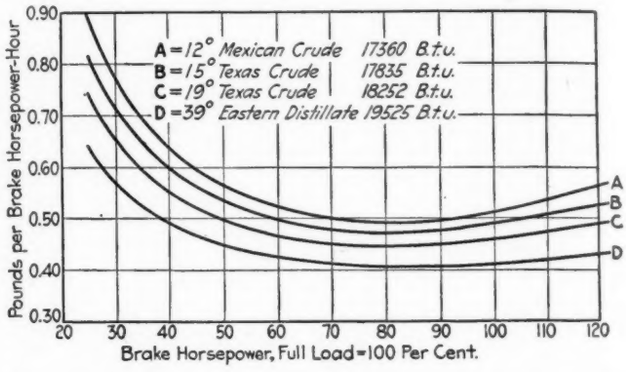


FIG. 10. FUEL CONSUMPTION CURVES FROM ALLIS-CHALMERS ENGINE

being such that the rotation of the eccentric sleeve simultaneously places the fuel valve out of action and holds the exhaust valve open, and vice versa. This form of compression relief compels a separate handling of each cylinder and does not relieve the cylinders that are used for starting; it therefore becomes less convenient, less prompt and less effective as the size of the engine increases. For the larger sizes a system has been adopted in which auxiliary cams are used to operate the exhaust valves of all cylinders, opening these at the commencement of the compression stroke and closing them upon its completion; the fuel valves being meanwhile out of action until the engine has been accelerated sufficiently, when, by the operation of a single wheel or lever, the relief is cut off all the cylinders and the fuel is then admitted to them one at a time.

The construction of the pistons and their accessories has been reduced to an almost uniform basis. In the larger sizes some builders provide the pistons with separate heads secured to trunk guides. Plain snap rings of cast iron have become universal, these being provided with ordinary lap joints. The piston rings are usually not doweled, to maintain fixed relative positions of the joints; except in the case of two-stroke-cycle engines, in which the rings over-travel ports in the cylinder wall and it is necessary to prevent the joints from traveling across the openings. When the pistons attain diameters in which the area exposed to the heat becomes so great that radiation cannot be relied upon to prevent excessive temperatures, it is usual to positively cool the heads. This is particularly the case in two-stroke-cycle engines, in which the pistons are exposed to combustion temperatures twice as often as in four-stroke-cycle machines. As a cooling medium, either water, a mixture of water and air, or oil is used.

REGULATING AMOUNT OF FUEL

Of importance equal to that of the fuel-atomizing elements is the regulation of the amount of fuel delivered to the cylinder, to suit the existing load. The quantity, even at full load, is so minute that an almost infinitesimal variation will materially affect the speed of the engine. For example, the quantity of fuel oil delivered to a 100-hp. cylinder, per working stroke, is only 0.0046 liter (0.28 cu.in.) at full load, and 0.0026 liter (0.16 cu.in.) at half load; or a difference of 0.002 liter (0.12 cu.in.) between full and half load. This fuel oil is delivered to the atomizers by means of a fuel pump having one plunger to serve each working cylinder; or one plunger to serve several cylinders, with a proportioning distributor to equalize the delivery to each to suit the average load conditions. Some of the methods used to regulate the fuel supply under the control of the governor are: Varying the stroke of the pump plunger; maintaining a constant stroke of the pump plunger, but bypassing back to the suction during the delivery stroke a variable quantity of the fuel; or maintaining a constant stroke of the pump plunger, with a constant pump-barrel volume during the suction stroke, and varying the pump barrel volume during the delivery stroke.

The pressure of the air used for atomizing and injecting the fuel varies with the type of the engine and the proportionate loading. It ranges from 35 or 40 atmospheres at no load to 65 or 70 atmospheres at full load, a slight variation being desirable to suit the character of the fuel oil. This air is generally compressed by a three-stage air compressor integral with, or directly coupled to, the engine. To avoid lubrication difficulties and the danger of explosion of lubricating-oil gases, as well as to reduce the dimensions and power consumption of the compressors, they require thorough water cooling and the provision of ample inter- and after-coolers. Single-acting compressors with the trunk pistons arranged in echelon have become general, as also have automatic valves of very limited lift. As previously described, the capacity and delivery pressure of these compressors is adjusted by throttling the low-pressure suction.

LUBRICATION OF DIESEL ENGINES

The main bearings of horizontal Diesel engines are generally constructed similarly to those of horizontal gas engines, with at least partial adjustability; whereas adjustable bearings have practically been abandoned in the modern makes of vertical engines, in favor of rigid bearings of such ample surface and provided with such efficient lubrication that their wear is negligible.

For cylinder lubrication it is desirable to use an uncompounded neutral mineral oil with a flash-point not lower than 180 deg. C. (350 deg. F.), a viscosity as high as the lubricating pump will handle reliably and the characteristic of retaining a high degree of viscosity when hot. The function of this oil is not only to lubricate, but also to serve as a packing medium by forming a seal between the piston rings, against the leakage of air or gases. The compressor pistons are generally lubricated by a pump or by high pressure sight-feed lubricators and use an oil similar to that for the working cylinders, except that a slightly lower viscosity and higher flash-point are preferable.

In vertical engines the prevailing method of lubricating the bearings and pins is the forced-feed system, although some builders still adhere to ring oiling for the main bearings and centrifugal oiling for the pins.

To those accustomed to steam engines or, still more so, to steam turbines, the consumption of lubricating oil by a Diesel engine usually appears high, but this is the only operating expense on account of which the machine can possibly be accused of extravagance. This consumption averages 0.3 liter (0.07 gal.) per hour per 100 hp. engine rating. Of this, about 20 to 25 per cent. is used in the cylinders.

The exhaust gases leave the cylinders at 670 to 700 deg. F. at full load, but the temperature rapidly falls with decreasing loads. To render the operation of the engine safe and comfortable, it is usual to water-jacket such portions of the exhaust headers and pipes as the operator might come in contact with. Through these jackets is circulated a portion of the water that has already done duty in other parts of the engine where the rise in the temperature of the water must be maintained at a lower point. The exhaust gases from a properly designed, adjusted and operated Diesel engine are invisible and remarkably free from combustible constituents.

The majority of crude and fuel oils contain appreciable quantities of sulphur. This, if not over 1½ per cent., will not seriously affect any engine parts other than the exhaust passages and, to a less degree, the exhaust valves; but even in small amounts in combination with the hot vapors of the water of combustion, it will attack the exhaust pipes near the engine. For this reason, these pipes are made of cast iron and the use of steel for this purpose is avoided.

The noise of the exhaust is muffled by the same means as are in common use with gas engines; but concrete exhaust-muffling chambers have been found undesirable, on account of the disintegrating effect of the hot oil vapors, which may temporarily pass from the cylinders by reason of some maladjustment of the valve gear.

OILS SUITABLE FOR DIESEL ENGINES

Fuel oils for use in Diesel engines should contain the lowest proportions of the following impurities, compatible with the prices demanded:

Water: More than ½ per cent. of water should be considered excessive, and if fuel containing more than this has been accepted, the water should be settled out by heating with a steam coil.

Sulphur: If in excess of 1½ per cent., the combination of the sulphurous fumes with the vapors of the water of combustion will corrode and pit the exhaust valves and seats and rapidly eat the exhaust piping.

Ash: A comparatively minute percentage of entirely non-combustible matter in the fuel causes, on the oily cylinder walls between these and the piston, an accumulation that will result in excessive wear.

Asphaltum: This much-abused term is susceptible to so many and various interpretations that it has no definite significance. Nor has the method for its determination been standardized. The various chemical and mechanical (penetration) determinations have little or no bearing upon the real issue under consideration, namely, the complete combustibility in a Diesel cylinder under the conditions existing in it and within the available time. A comparison of results obtained in actual use, with oils containing a substance other than ash, which will not volatilize under certain definite conditions, appears to be the best guide as to the proportion of this substance that will render necessary an excessively frequent cleaning of the cylinder and its adjuncts. Several years of careful observations and records have induced the oldest Diesel-engine builders in this country to adopt, for such comparisons, the percentage of residue remaining after the sample of oil has been gradually brought to a temperature of 300 deg. C. and then subjected to this temperature for 120 hr. in a closed furnace in which combustion does not take place. Under this treatment the sample is reduced to practically constant weight. It has been determined that, so long as this residue is less than 10 per cent. of the original weight of the sample, unreasonably frequent cleaning is not necessary. This percentage is equivalent to anywhere from 7 to 30 per cent. of "asphaltum," according to the various methods of determination in use. If the fuel oil contains more than 10 per cent. of residue, its use must be guided by the relative cost of the oil and the cost and inconvenience of labor and stoppages required for the more frequent cleaning. The form of the atomizer does not appear to have any bearing upon this question, as the substance does not become objectionable until after the fuel has entered the cylinder and its more volatile constitutents have become gasified; although it may render necessary warming of the fuel.

Fig. 10 illustrates the consumption of the fuel oils of widely varying gravity, in the same engine.

Variable-Speed Drives for Rolling Mills

In a paper before the Association of Iron and Steel Electrical Engineers, at Detroit, K. A. Pauly described the features of two relatively new systems by which the speeds of induction motors can be economically varied over considerable range for rolling-mill work. These are the "Scherbius" and the "rotary-converter" systems. In the former the slip energy (that is usually dissipated in a rheostat) of the main induction motor is delivered to a polyphase commutator motor connected to the slip rings of the main induction motor, and either returned to the power system through an induction or synchronous generator, driven by the polyphase commutator motor, or to the main roll shaft by mounting the commutator motor on the mill shaft.

The second, or rotary-converter, system differs from the first in the method of returning the slip energy to the power system or to the main roll shaft. Here the slip energy is converted to direct current by a rotary converter connected to the slip rings of the main roll motor and is either returned to the general distributing system through a motor-generator or is delivered to a direct-current motor mounted on the main roll shaft.

These systems were described by the same author two years ago before the same society, but at that time there had been no installations of either system in this country; since then installations have been made.

The control of the mill with either system, both during starting up and changing speed, is as simple from the operator's standpoint as would be the case were it driven by an adjustable-speed direct-current motor. The acceleration of the main motor is entirely automatic, and the regulating set, which is kept out of circuit during the first part of the acceleration because of the high frequency of the rotor current of the roll motor during this period, is automatically connected to the main motor when the latter has reached a predetermined speed.

It has been found with the rotary converter system that if all the determining factors, such as speed range and overload requirements of all loads, together with the speed and design of the induction motor driving the rolls, are favorable, converters and motor-generators of standard design can be used. However, unless this is the case these units must be modified to meet the requirements.

The roll motor, when controlled by the Scherbius system, can be safely adjusted so as to operate at speeds very close to its synchronous speed (within approximately 5 per cent.) and then subjected to 250-per cent. load. This makes it pos-

sible to take advantage of the synchronous speed of the roll motor as one of the speeds in the operating range by simply short-circuiting its collector rings. When so operating, the regulating set may continue to run, if desired, driven by the induction generator operating as a motor, and may be again thrown into circuit by simply opening up the short-circuit on the collector rings when it is desired to again reduce the speed. On the other hand, from five to ten cycles is as low a frequency as the converter driven from the rotor of the main roll motor can safely be operated at if the main roll motor carries 250-per cent. load at higher speeds. The power factor of the main roll motor, which is usually low because of its slow speed and large air gap, can readily be increased, and in fact frequently raised to unity, at full load with the Scherbius system of control, without entailing any appreciable additional cost for the equipment. On the other hand, while theoretically power-factor correction can be to a certain extent obtained with the rotary converter, it is seldom safe to do this because of the instability of the converter when operating at leading power factor.

Refrigeration in France*

By L. Marchis†

The first part of the paper is given to a description of the methods of the industrial production of liquid air, oxygen, nitrogen and hydrogen as accomplished by the refrigeration method used by G. Claude. In the production of the liquid air a temperature of —143 deg. C. (—225.4 deg F.) is used, while in the production of liquid oxygen a temperature of —182.6 deg. C. (—295.6 deg. F.) is used, and for liquid nitrogen —194.4 deg. C. (—317.2 deg. F.). The liquefying of air is especially important because it tends to become the only industrial source of oxygen and of nitrogen. The production at a low cost of these two gases is a problem the solution of which is of great importance to metallurgy and to the fertilizer industry.

Although Claude has not carried his process as applied to the extraction of hydrogen from water gas to the point of industrial production, he is making experiments in this direction and liquefying 150 to 200 kg. (330 to 400 lb.) of carbon monoxide per hour. This substance mixed with oxygen may be employed to form an explosive for use in internal-combustion engines.

Also by the use of refrigeration, Claude has made possible the extraction from atmospheric air of the rare gases helium, neon, argon, krypton and xenon. Neon is now employed in tubes, which light with a rose color as the result of a passage of high voltage electricity. These lamps give approximately 200 cp. per running meter of tube, and require about 0.6 watt-hour per candle. By the introduction of a little mercury into the neon tubes a beautiful blue light is obtained.

Hydrogen boils under atmospheric pressure at a temperature of —252.6 deg. C. (—422.6 deg. F.), but this substance is still difficult to procure in considerable quantities. Claude has indicated a simple method for obtaining for a few minutes a temperature of —211 deg. C. (—347.8 deg. F.) when liquid nitrogen is available.

Chapter 2 of the paper is given over to a discussion of heat insulators and Chapter 3 to refrigeration machines.

The refrigerating machines built in France fall into five types—ammonia, sulphur-dioxide, carbon-dioxide, methyl-chloride, and water under partial vacuum. The four classes of machines are of the so-called compression type; machines of the absorption type are no longer built in France. There are only a few in operation in ice plants. Methyl-chloride is used only in the Douane machines. This is, moreover, not employed in other countries. Further, the type using water under partial vacuum is peculiar to the Westinghouse company, which builds it under the direction of its inventor, M. Maurice LeBlanc. This machine will be referred to later.

Recently a single-acting compressor under the name "Equator" has been proposed, with a rotative speed of 500 r.p.m. At a certain point in the stroke the piston uncovers certain openings by which enter the gases coming from the evaporator. As to the exhaust valves, they are formed of simple bars of steel placed over the openings connecting with the condenser. This compressor, still under tests, has given good results.

Machines operating with sulphur-dioxide are more numerous than those with ammonia, but their total refrigeration capacity is less than that of those using ammonia.

A type of compressor altogether peculiar to France is the Audiffren-Singrün. It has neither stuffing-box nor valves. The compressor is imprisoned in a hermetically sealed inclosure, on the interior of which acts the pressure of the liquefier. The compressor may be operated by an external motor without piercing the wall of the space that contains it; that is to say, without employing a stuffing-box. To this end it is sufficient to revolve the closed compartment containing the compressor. The mechanism of the latter, to which is given an alternating movement, is maintained fixed in space by means of a mass of lead of sufficient weight to balance the shell containing the pump of the compressor. This machine is especially used for the manufacture of ice in small quantities for domestic use, yielding 3 to 4 kg. (6.6 to 8.8 lb.) per hr. For such purpose it is furthermore practical, for it requires no supervision and can be put into operation by any domestic. However, larger machines are now in hand capable of making from 50 to 100 kg. (110 to 220 lb.) of ice per hr.

Maurice LeBlanc, of the Westinghouse company, has brought into service a machine in which water is used as the refrigerating fluid. It produces the cooling of brine by inducing its evaporation under a suitable reduction of pressure. This partial vacuum is realized by means of a jet of vapor which, issuing at high speed from an orifice surrounded by a suitable diffuser, entrains large quantities of water vapor. However, to obtain in the evaporator a temperature of the brine sufficiently low—that is, a sufficiently low tension of the vapor emitted by the solution—it is necessary to realize at the condenser of the vapor a very low pressure. This is realized by the use of an ejector condenser; that is, one in which the vacuum pump is constituted by a liquid ejector. This machine presents the advantage of having neither poppet valve nor check valves subject to rapid wear. It is also silent.

An important saving is made by the use in the vapor ejectors of exhaust vapor from other vapor motors, as turbines, for example. Thus at the refrigerating abattoir at Chasseneuil, the exhaust from a steam turbine under a pressure of 28.4 lb. per sq.in. passes into the ejectors and produces in the evaporator a vacuum of 2 mm. (0.08 in.) of mercury. The efficiency of an ejector machine is the ratio of the number of units of refrigeration produced in the evaporator to the number of heat units absorbed by the refrigerating water in the condenser. If consideration is given to the temperatures corresponding to the tensions of the vapor of water in the evaporator and the condenser, the efficiency diminishes rapidly when the difference in these temperatures increases. It has a value about 30 per cent. for a difference of temperature equal to 15 to 20 deg. C.; that is, a temperature of 5 to 0 deg. in the evaporator for a temperature of +20 deg. C. in the condenser. For this reason the ejector machine is well suited where it is not necessary to refrigerate below zero Centigrade.

It is on shipboard that ejector machines may find their most significant field of use. They employ a refrigerating fluid that involves no danger of fire and which can be renewed with sea water; likewise ejector machines serving to cool a few degrees below zero Centrigrade the air circulating in ammunition rooms have been installed on a number of French battleships and on Russian and Austrian ships of the same type. Machines of this kind have also been employed for the refrigeration of food stores for passengers on four steamers of the French merchant marine. The total number of machines installed on shipboard is fifty-eight, with an aggregate refrigerating capacity of 2,000,000 frigorie-hours.

The ejector machine presents the serious drawback of requiring at the condenser a considerable amount of cooling water. On this account for stationary installations, M. Le Blanc has undertaken the construction of a pump mechanically operated and capable, with a small volume, of aspirating the enormous volumes of water vapor required by the use of this substance as the refrigerating fluid. To this end he has turned to the rotative type of pump.

But the problem presents serious difficulties. The rotary compressor must be of small dimensions. It must require only a small power for operation and must nevertheless, be capable of aspirating several cubic meters per second of a

*Excerpts from a paper read at the meeting of the International Engineering Congress, San Francisco, Calif., Sept. 20-25.

†Professor, Faculty of Sciences of Paris, Paris, France.

vapor of density much less than that of air. But the less the density of the aspirated air, the greater must be the peripheral velocity of the vanes; the more the power absorbed by the compressor is reduced, the more must the angular velocity be increased.

Suppose that we have such a turbo-compressor formed of four rings of veins of decreasing diameter in series, of which the largest has a diameter of 320 mm. (12.6 in.). The peripheral speed that the large wheel must have being 500 m. (1,640.4 ft.) per sec., the rotor must turn at a speed of 30,000 r.p.m. A mass weighing 1 gram (0.0022 lb.) placed on the periphery of the large wheel would be subject to a centrifugal force of 160 kg. (352 lb.). To construct vanes able to resist forces of this magnitude while at the same time sufficiently light, LeBlanc has employed threads of ramie stretched parallel and consolidated by dissolved cellulose.

Chapter 4 of the paper describes a traveling refrigeration plant that uses the Aubiffren-Singrün type of machine, to demonstrate on the spot to agriculturists the advantages that may be realized by the use of refrigeration. Refrigeration has also been applied with favorable results to the wine industry, one of the chief benefits being that the wine that is subjected to cold is refined more rapidly and may in consequence be presented to the trade after a shorter period of ripening. The paper also contains a table showing the total installed capacities of different systems of refrigeration as applied to various industries in France.

In British Engineering Circles

At the 85th annual meeting of the British Association for the Advancement of Science, held in Manchester, Sept. 7-11, several papers relating directly or indirectly to power production and fuel economy were read and discussed. Professor Bone, in the course of his presidential address, expressed the belief that fuel economy and the proper utilization of fuel would become one of the most important national questions in all countries. There was great need, in view of the present and future positions with regard to fuel, for the extension and more systematic chemical control of byproduct coking plants. It was tolerably certain that an additional and systematic public supervision of fuel consumption would save many millions of dollars annually, and with improved appliances still more might be saved. He closed with a plea for the establishment of some central organization for the supervision and control of fuel, to be charged not only with the duty of making a systematic survey of the coal fields of Great Britain and her colonies, but also with the carrying out of experimental trials of new apparatus and of inventions designed to promote fuel economy.

SMOKE AND ITS PREVENTION

One of the sessions was devoted to a series of papers on "Smoke and Its Prevention." As a result of a petition signed by members of various scientific societies in Manchester, the City Council created in 1913 an Air Pollution Advisory Board, with the object of working for the purity of the atmosphere by research and propaganda as opposed to the older municipal method of prosecution.

Roughly, the possible lines of research were divided into damage by smoke, means for reducing factory smoke, and means for reducing domestic smoke. The board having considered these possible lines as well as the means at their disposal, had undertaken two researches. First, they decided to join in the national investigation as to the disposition of soot and are now measuring this at ten different stations in and near Manchester. At the same time they are measuring the amount of sunlight cut off at these stations. Their second line of research is the fitting up of a room at the School of Technology for the purpose of carrying out tests on various kinds of domestic-heating appliances. This work is controlled by a special subcommittee, which includes representatives of the Manchester City Gas and Electricity Committee, whose coöperation is likely to be of considerable value. The tests will probably begin with the measurement of radiant heat. They may also include other heat measurements, analyses and measurement of flue gases, tests of gas fires for leakage and many other tests.

The practical outcome of the papers on smoke and its prevention was the passing of a resolution to appoint a British Association Committee to coördinate and encourage the work of the various town committees that have taken up the investigation of air pollution.

MANCHESTER'S NEW POWER STATION

At one of the other sessions L. S. Pearce, city electrical engineer of Manchester, contributed a paper on the plans for the new electrical generating station on Barton Moss, five miles from the center of the city. Had the war not disorganized the work, the station would have already been partly completed. A special feature will be the arrangement for using the effluent water of the sewage-treatment works at Davyhulme for condensing purposes.

The station, which will have an ultimate capacity of 160,000 kw., will be erected in four sections, each of which will contain two complete steam and electrical generating units with their auxiliaries. This will allow one spare unit, another to be set aside for repairs and six for regular operation. The first four will include turbo-generators of 15,000 kw. each and the remaining four, turbo-generators of 25,000 kw. each. The arrangement includes four boiler houses, each with two batteries of water-tube boilers and four coal pockets, which practically form an extension to the boiler houses but are separated therefrom by a canal dock for the reception of coal. Preliminary estimates show that 500,000 tons of coal a year will be required by the complete plant, and the canal can handle at least 1,000 tons a day, while the railroad will be able to supply 300 tons an hour.

A suction system is proposed for the removal of ashes and soot, the discharge leading to receivers on the canal-dock side, where the ashes may be discharged into barges or into railway trucks, the soot and ashes being kept separate.

For the first section of the station there will be installed 8 water-tube boilers, each with a normal rating of 50,000 lb. of steam per hour and a maximum of 60,000 lb., complete with its own superheater, economizer, induced-draft apparatus and chimney, the Prat system having been proposed. In the basement of each boiler house there will be installed two steam-driven and one electrically driven boiler-feed pumps, each with a rated capacity of 25,000 gal. per min.

It is proposed to erect a pumping station near-by, equipped with electrically driven high-lift pumps, and a local substation for controlling the general supply to the sewage works. The purified effluent will be drawn from a large storage reservoir and will be pumped up to the generating station, where it will pass through a specially designed valve chamber before entering the condensers. Moreover, the discharged effluent will gain some 15 deg. in temperature in passing through the condensers, which will result in important economies in the subsequent purification process.

The transformers and the high-tension switching apparatus will be housed in a separate fireproof building. It is planned to make the installation of indicating and recording instruments very complete. These will include, besides the usual pressure gages, those for recording steam and water temperatures, temperatures of electrical generators, transformers, oil switches, temperatures in the coal storage and of the inlet and outlet cooling air. Since the electrical output is largely a question of permissible temperature rise, these instruments are particularly important.

The estimated capital cost of the completed station is $53 per kw. Preliminary estimates of the operating cost on a 40-per cent. load-factor basis, with coal at $2.16 per ton, figures 0.276c., and the capital charges, 0.176c., making a total cost, exclusive of administration charges, of 0.452c. per kw.-hr. This figure compares favorably with the costs at the Stewart Street station (Manchester), where, with a 37-per cent. station-load factor, the total cost is 0.766c. per kw.-hr.

THERMAL EFFICIENCY OF GAS ENGINES

Professors Asakawa and Petavel also contributed a lengthy paper describing an "Experimental Investigation of the Thermal Efficiency of a Gas Engine." In the following summary the performance of the engine is compared with that of a perfect engine working on the same cycle, and with a similar gas mixture:

Indicated Horsepower—At full load under the most favorable conditions the indicated horsepower of a gas engine is 88 per cent. of that of an ideal engine working with a similar mixture.

Brake Horsepower—At full load the brake efficiency relative to the gas standard varies from 70 per cent. at the compression ratio 3.75 to 67.5 per cent. at the compression ratio 5.6. This holds true for all except the weakest mixtures, for which the relative efficiency is lower. The absolute brake efficiency is 21 per cent. at compression ratio 3.75; and 25.5 per cent. at compression ratio 5.6, for mixtures containing little excess of air, and 23 and 27 per cent. respectively for mixtures containing twice the amount of air required for complete combustion. The maximum brake efficiency obtained in the present experiments was 27.4 per cent., which occurred at the highest compression ratio for a mixture slightly stronger than this.

Mechanical Losses—The mechanical losses increase slightly in absolute amount with the load and with the compression ratio. For the engine under test (a 25-hp. National gas engine) at normal speed of 200 r.p.m., the mechanical losses

amounted to 5.6 hp. at no load and 6.3 hp. at full load, when the compression ratio was 3.75; and 6.5 hp. at no load and 7.0 hp. at full load when the compression ratio was 5.6.

Thermal Losses—The loss of power due to thermal losses at full load under most favorable conditions amounts to 12 per cent. of the total available energy, and at no load to 16 per cent. Of this less than one-quarter is due to heat transmission during the expansion.

The Engineering Society

On the evening of Sept. 20, Ernest M'Cullough delivered a lecture on "The Engineering Society" before the Western Society of Engineers. The author dwelt upon the causes leading up to the formation of the American Association of Engineers and blamed the older societies for not giving more attention to the young engineer. Starting with the formation of the first engineering society over a century ago, he reviewed the advance made since that time and spoke of the methods adopted by the earlier societies. They brought together men having similar interests, where the older men read and discussed papers that were intended purely for instructional purposes, most of the engineers being trained by apprenticeship. Few schools existed, and the young men picked up their knowledge as best they might in the offices of eminent practitioners, and at the society meeting met other men of experience. In this way they obtained a broad view of their business, so necessary for future success. The educational value of the meetings was so great that a professional spirit developed and was fostered.

Then the great material development of the world commenced. The engineer became the technical man, his vocation was recognized alongside the older professions of law, medicine and theology, so that it is no longer a reproach for a man to be called an engineer, but rather an enviable title.

The technical or engineering societies have not developed with the work of the engineer. They are still lingering in the past and consider themselves as institutions organized solely for educational purposes. This is the way they are conducted, but the majority of the members know many societies exist rather as an evidence of the standing of the members than for their declared purposes. The modern technical journal is doing far more real educational work than any society, no matter how large or how important it may be. The pages of the weekly and monthly papers bring to us news from the front, fresh and in a way that the more formal papers of a society cannot. The society proceedings have become mere encyclopedias, which are consulted less frequently than are the pages of the journals maintained purely for profit.

There is a well-founded idea that engineering societies have for many years past been mutual-admiration societies of successful men and have been used for the furthering of insidious advertising by men qualified to take full advantage of the position their membership brings them. The papers are generally obtained only by hard work on the part of the publication committee in each society. The discussions are too frequently inadequate, and real criticism is seldom developed when the author of the paper is of commanding eminence. The young man learns something, but not much, from the papers and feels diffident about discussing them, as he fears his opinion would not be well received.

The young engineer does not want this. He wants scholarship, companionship and definite recognition. He is glad to attend a meeting where he knows refreshments will be served, not because of the refreshments, but because something to eat and drink signifies a lack of formality and perhaps an opportunity to mingle freely with older men who have made their mark. He wants to make acquaintances with men having like interests with himself and to feel that the society is more than an editorial body or an encyclopedia compilation of engineering facts—that it is composed of flesh and blood men who want to help him because of their knowledge of the trials and tribulations he is undergoing. He would rather know how to obtain a position and how to hold it than to hear how other men have done engineering work, for he reads the technical journals and gets a surfeit of such material.

The author spoke briefly of the formation from time to time of societies organized by young men and intended to help them meet their particular troubles. In these organizations the employment question is uppermost, and while they may perhaps thrive while times are dull, they all fail when members have positions and forget to continue paying dues. This led up to a discussion of the object of the American Association of Engineers which, as stated in a previous issue, was originated to raise the standard of ethics of the engineering profession and to promote the economic and social welfare of engineers. As may be remembered, these objects are to be obtained by affording means for an interchange of information, by maintaining a service clearing-house, by affording patent and legal advice, by supervision of legislation and by proper publicity.

In analyzing the objects cited and the methods by which they were to be obtained and how they conflicted with the objects of the older associations, the author was of the opinion that the older societies were not attending to business. The work outlined should be attended to by the veteran. "Old men for council, young men for action," should be the motto of the older societies. If this were the motto and lived up to properly, the young men should obtain all the objects sought and the societies would grow faster than they are now growing. The members should receive the worth of their money—the older men in the feeling of satisfaction following every worthy action, the younger men in the experience of material benefit.

Discussing the methods outlined, the older societies can honestly say only the first has been attempted by engineers—that of affording means for an interchange of information. That a service clearing-house has not been properly attempted is a reproach. The engineer is a wanderer from job to job. When capital is active he is hard to find. When dull times come and capital rests, the streets are full of technically trained men out of work. They wander from office to office, many of them starving and too proud to admit it, many never getting a substantial footing. Their work is concerned with new enterprises and with the day laborer they share the ups and downs of fortune. There is a place for all, and it is the duty of the older engineers to take care of their brothers. Every day the Western Society and the other large societies delay in organizing a service whereby members out of employment can be placed in positions is an inexcusable reproach. The organization is already formed. It requires only the spirit. Any society should not limit its efforts in this direction to members, but should give members the preference, all things being equal. All members needing men should file their wants with the secretary of the society and not attempt in any other way to secure men until the secretary says there are none available. All members might be classified by specialty and lists printed, so that those wishing to get in touch with men in any special line of work may have such a list given to them by the society and then make a choice.

The affording of patent and legal advice needs to be approached with care. The society should have an attorney who can help members that have trouble in collecting pay. That is, members who fall into the hands of unscrupulous employers.

The fourth method is concerned with legislation for the technical man. The architects are working hard to obtain legislation to make architecture a closed profession, beginning with the passage of the license law for architects in Illinois in 1897. A number of the states have similar laws, the greater number of which were passed during the present year. Engineers were opposed to legislation to license engineers, but conditions in the State of Illinois became so intolerable on account of the monoply given to architects that the Western Society this year obtained the passage of a law to license structural engineers. This one thing has done more to help the society than any other single thing since it was organized. The next piece of legislation to be attended to is one fixing the status of sanitary engineers, or the plumbers will get ahead and obtain control of the design and construction of sanitary work. It is not the intention to make a closed profession of sanitary engineering, but to prevent injustice to such engineers because of legislation that may be secured in other lines of work, it will be necessary to have examinations and licenses for them.

A better way would be to secure a law requiring the registration of technical engineers with an examining board qualified to examine men in different specialties, so that the word "engineer" will possess a dignity comparable with the titles of the other learned professions. Not only must the modern engineering society see that legislation is secured to protect and elevate the engineering profession, but it must also carefully look after proposed legislation to the end that no laws which work harm to the people of the state will get on the statute book. That is, as a citizen the engineer must protect those that lack knowledge of technical affairs and are left at the mercy of special interests.

As to what is proper publicity depends upon changing ideas and advances in civilization. The advertising methods of the live, wide-awake business man may be considered coarse and unbecoming for the professional man. Is this idea a survival of a generation past? Is it, as many young men claim, a fetish worshiped by professional men for the purpose

of helping older men maintain their preëminence and hold the young man back? The question must be answered individually just now. Throughout his life the technically educated man, the engineer, is at times a professional man, a technical employee and a business man. He must do some publicity work, and society should not be hide-bound in what is to be considered proper means of publicity to be employed by individual members. It should be enough for the societies that the members remain decent and bring no discredit on the work of the technical men.

The societies heretofore have concerned themselves with the publicity work of individuals. What is now a crying need is publicity work of the proper sort by the societies for the benefit of the membership and incidentally of the technically educated men not members of any society. Through proper publicity work all technical men not members will want to become members. Incidentally, the work of technical men will be so placed before the public that there will be an increase of good material in the ranks. Proper publicity should have the effect of sifting out desirable men from those not so desirable. It is because of improper publicity work that there are so many complaints today of too many unfit men enrolled as engineers. These men, no matter how unsuited they may be to the work of the engineer, have a place somewhere in the world where they can fit in, and it should be part of the duty of the engineering societies of the future to find the holes in which these misshapen pegs may fit.

Western Water-Power Conference Favors State Rights

State control of the water-power resources of the West versus Federal control, as provided in the so-called Ferris Bill, to be reintroduced at the coming session of Congress, was the issue before the Western States Water-Power Conference, which held a three-day session in Portland, Ore., on Sept. 21-23, with delegates from 13 states present. Gov. James Withycombe in the address of welcome stated in part:

We are thirteen states of the West. Our states are young and sturdy, aspiring to great attainments, but each is held in leash, a leash grasped by a Federal Government none too indulgent, none too sympathetic with the best meaning of the phrase "state rights," and certainly none too familiar, in some phases of its bureaucratic paternalism, with the facts as they exist in the West today. We all know the numerical impotence of our sparse representation in Congress and we have no real opportunity to wield any appreciable power in connection with possible adjustments of Federal control of our economical developments. As matters stand, what we get, practically speaking, will be solely by the grace of the members from the Eastern States, many of whose constituents, having utilized their own natural resources in years gone by, consider it little short of criminal that we should even consider transforming our streams into wealth. Broadly speaking, our 13 Western States will face the dubious privilege of taxation without representation—and that phrase should at least strike a chord of sympathy in those 13 other states whose rallying cry it became at our nation's birth.

Gov. William Spry of Utah stated that "the Ferris Bill is fundamentally wrong, for it takes away from the states control of their own waters. It gives them absolutely nothing in return. Of course there is the provision that the states get 50 per cent. of the money received under the bill. What we want is not lease money, however, but control of our own resources." W. D. Beers, state engineer of Utah, cited several recent cases in that state where there was considerable conflict over Federal supervision. Men had filed on water rights with the state, at the same time filing application with the Government for reservoir sites, and the Government had deliberately ignored the filings granted by the state and had nullified them by giving later applicants the reservoir sites. At present a big irrigation and power project in Utah is being held up by the Government. The power development is necessary to make the irrigation development possible, the company's plan being to develop electrical power from the same dam used in the irrigation project. The Utah, Colorado and Idaho delegations were unanimously in favor of state rights in preference to Federal control.

Gov. Ernest Lister of Washington stated that the logical remedy for high power rates is to keep in the hands of the people the most valuable of all hydro-electric assets—the power site. "I do not believe in giving away our power sites," he said. "When a power site is in the hands of the corporation for development that site, really the property of the people, is heavily capitalized and the consumer pays interest upon that capitalization when he buys current." The Ferris Bill provided for a leasing system by which private capital could take Federal power sites for a term up to fifty years with a guarantee that the investment will be protected, unless for violation of the lease agreement; a matter on which a court shall pass. At the end of the lease period, the Government has an option to buy it at its valuation. Other supporters of the Ferris Bill were Clay Tallman, commissioner of the general land office and personal representative of Secretary of the Interior Franklin Lane; Chief Forester Graves; O. C. Merrill, chief engineer of the forestry bureau; and Senator Walsh of Montana.

The session closed with the majority adoption of the resolution declaring for state control of water-power resources and development, and voicing opposition to any policy looking toward a system of leasing generally of the public domain. The vote stood 28 in favor of the resolution and 7 against, with 3 absent. Commissioner Tallman, in closing the debate against the Ferris Bill, had the following to say in defense of the Government's plans for the leasing of power sites: "The Secretary of the Interior does not believe in granting away power rights in perpetuity and that, it seems to me, is the crux of the whole question." The delegates desired to reach a compromise between the demands of those who insisted upon state rights and of those who were in favor of the Ferris Bill. Any Federal lease should have as its primary principle a fixed life during which development may continue, a life long enough to allow the investor to reap a proper profit, long enough to allow for financing by bond issue. Mr. Tallman insisted most emphatically that the Government had the right ultimately to retake the valuable water power after reimbursing the man who had invested his money in it. Chief Forester Graves, also representing the Administration, said in defense of the Ferris Bill:

The day of uncontrolled perpetual grants or even the ninety-nine-year franchise is past, never to return, not only for street railways, but also for light and power companies. If the principles in the Ferris Bill are incorporated into law, I am confident that the difficulties still remaining in administering the public power sites will be removed, and I base that opinion both on the developments now taking place under a defective law and on the assurances of men in the power business.

A definite plan for developing the hydro-electric resources of the West was proposed to the conference by John H. Finney, electrical engineer of Washington, D. C., and representing the American Institute of Electrical Engineers. This plan involved the creation by Congress of a water-power commission consisting of the secretaries of the Interior, War and Agriculture. It further provided:

Each state charter to contain specific provisions as to the use of water-power; regulation of rates and charges at the hands of a state commission; rights of recapture by the state for a public use on a fair and equitable basis at the end of an agreed period, whether that be fifty years or more; rights of the grantee if recapture is not effected, together with such other safeguards as may be wisely bargained for between the state and its created agency of operation in any given case.

The Federal commission thus having a responsible agency with which to deal, with its purposes named, its financial methods approved, its proper regulation assured, need only be concerned to impose the minor restrictions which the general public interest demands. These are: (a) The obtaining of a fair value of, or fair rental on, any Government lands which the enterprise may require; (b) safeguards as to navigation, such as locks and storage of water on navigable streams; (c) supervision or approval of plans for proposed structures and dams, as to the safety thereof; and (d) the possible supervision or regulation of rates or reservation to regulate, when the project is engaged in interstate commerce.

There is without any doubt a sincere desire on the part of the present Administration to work out some definite legislation for the development of power, both on navigable streams under a new general dam act, as well as for power located on streams in the public domain and in National Forests. It is believed that this desire will be reflected in new bills to be presented at the next session of Congress, and, as the Ferris Bill passed the last House and has the backing of the Interior Department, it is likely that it will again be introduced and urged for passage, as will perhaps also be the case with the Adamson Bill.

He continued by summing up the wants of both states and of capital seeking an investment as follows:

What does capital want?

First—It seeks the opportunity to invest ordinarily as a public utility in an urgently needed legitimate business in the hope and expectation of profit.

Second—It requires conditions that will make for stability of the investment and of the enterprise for all time, or until such time as the property becomes necessary for public use.

Third—It requires assurance of repayment in full for capital expenditures used in the upbuilding of the property, if and when the state or nation should exercise its rights of purchase.

What does the state want?

First—Development so that the state's activities can be furthered.

Second—Electric service at the lowest price that conditions justify, but service first; and also through the regulation of rates at the hands of its public-utility commission to prevent oppressive monopoly.

Third—Reliability and continuity of efficient service, capable of indefinite expansion at the hands of a well-organized and financially responsible agency.

Fourth—It may want the possible right of recapture for some public use at the end of some definite period.

In conclusion Mr. Finney stated that the states of the West want the right to grant development permits, regulate and control rates without action by Congress.

PERSONALS

W. E. Hardy, for the past 11 years with the Diamond Rubber Co. and the B. F. Goodrich Co., and lately in charge of the sales of the Goodrich Mechanical Rubber Goods Division, has been appointed sales manager of the Boston Belting Co., Boston, Mass.

R. E. Mathot of Brussels, president of the Technical Committee of the Automobile Association of Belgium, consulting engineer and occasional contributor to our columns, is in New York commissioned by a syndicate of French capitalists to contract in America for automobile parts, which, being assembled in France, will constitute a moderate-priced car, a Continental Ford as it were, and will be glad to get into communication with the builders of such parts and accessories. He may be addressed in care of "Power".

J. H. Prior has been appointed chief engineer of the State Public Utilities Commission of Illinois. The commission is charged with the regulation of all public utilities in the State of Illinois and has under its jurisdiction steam and electric railways, gas and electric plants, telephone and heating plants, warehouses and water-works except such utilities as are municipally owned. Mr. Prior was educated at the Armour Institute of Technology and the University of Chicago. He was engineer of design of the Chicago, Milwaukee & St. Paul Railway from 1905 to 1914, engaged in the design of all classes of railroad structures, structural betterments, and track elevation work for that company. In the years 1906 to 1907 he made valuations of that railway company's structures in the states of Minnesota and South Dakota, required by the railroad regulatory and taxing bodies of those states. Previous to his appointment as chief engineer, Mr. Prior was assistant chief engineer of the commission he now serves. He is a member of the American Society of Civil Engineers and has been from time to time an officer of the Western Society of Engineers.

ENGINEERING AFFAIRS

The Detroit Engineering Society visited the plant of the Ford Plate Glass Co., at Toledo, Ohio, on Oct. 6. The trip was made in special trolley cars that carried the members directly from Detroit to the Ford plant without change.

The American Society of Mechanical Engineers will hold a meeting at New York on Oct. 12, at which Frank B. Gilbreth will give his paper entitled, "Motion Study for Crippled Soldiers." The paper discusses the problem of adapting men crippled in the great war to machines for manufacturing operations or of redesigning the machines to fit the men.

Engineering Draftsman Wanted—The Civil Service Commission of the State of New York will hold on Oct. 30, in the various cities throughout the state, open competitive examinations for the position of Engineering Draftsman, compensation $1,201 to $1,500 annually. Applicants must have had two years' experience in drafting or engineering work. Technical education will receive credit as equivalent to experience, graduation in engineering from a school of the highest standing being counted as one year's experience. The subjects of examination and relative weights are: Problems and questions in applied mathematics and mechanics, design and erection of engineering structures, and drafting, 6; education and experience, 4. Candidates will be allowed to use books of reference in the examination and must provide drafting instruments, ink, drawing board, and paper 14x22 in. The time allowed is eight hours, and the examination is open to citizens of the United States who have been residents of New York State for at least three months prior to the date of the examination. Application blanks may be obtained before Oct. 18, from the State Civil Service Commission, Albany, N. Y.

According to a Paper by James Howden, inventor of the Howden forced-draft system so widely used in marine practice, the honor of first using a blowing fan to accelerate combustion in a steamboat belongs to Edwin A. Stevens, of Bordentown, N. J., who in 1827 in the "North America," fitted boilers with closed ashpits into which the air of combustion was forced by a fan.

NEW EQUIPMENT

N. Y., Buffalo—Delaware, Lackawanna & Western R.R. Co. plans substation on Ohio St. Estimated cost, $8,000.

N. Y., Troy—Plans being prepared for power plant at mill of J. B. Hurst.

N. J., Cape May—Citizens voted to issue bonds for electric-light plant.

Penn., Milton—Election will soon be held to vote to install municipal-electric light plant in Milton.

Ga., Atlanta—Atlanta Electric and Ice Co. has acquired plant of municipal water works and will operate same for five years. Company plans to install new equipment in electric-light and power plant and water-works.

Ga., Toccoa—City will build power plant on Toccoa Creek.

Ala., Thomas—Municipal electric-light plant leased by R. R. Thomas, who will improve same.

La., Colfax—Power plant of Big Pine Lumber Co. recently destroyed by fire, will be rebuilt. New equipment will be required.

Tenn., Henderson—Citizens voted $13,000 bonds for equipment for electric-light plant.

Tenn., Tullahoma—Cumberland Springs Co. plans electric-light plant and other improvements.

Ky., Hawsville—Hawsville Water and Light Co., will soon be in the market for a 100-hp. boiler.

Ohio, Lorain—Election will be held in November to vote $350,000 bonds for municipal electric-light plant.

Ohio, Marietta—Election will be held in November to vote $45,000 bonds for municipal electric-light plant.

Ind., Evansville—Fire recently damaged power house of Evansville Public Service Co. Estimated loss, between $75,000 and $100,000.

Ind., Goshen—Hawks Electric Co., will soon be in the market for boilers, engines, condensers, exciter and switchboard.

Mich., Monroe—Bids being received by Mills, Rhines, Bellman & Nordoff, Arch., 1834 Ohio Bldg., Toledo, Ohio, for factory and power house for Weis Fiber and Contained Corporation.

Mich., Three Rivers—Bids will be received by the city until Oct. 21 for electric-light plant and water system. Plans and specifications may be obtained from Eugene A. Schall, City Clk., or G. Champs and F. H. Froelich, Engr., National Bank Bldg., Toledo, Ohio.

Ill., Chicago—Lincoln Park Commissioners plan to install two 300-kw. turbo-generators to be driven by steam from steam-heating system.

Ill., Galesburg—Election will soon be held to vote $100,000 bonds for improving electric-light plant.

Wis., Ashland—Henry Wildhagen, Arch., preparing plans for electric-light plant for Ashland Light, Power and St. Ry. Co. Estimated cost, $75,000.

Wis., Clintonville—City is in the market for small amount of power and electrical equipment for water and light plant.

Iowa, Clinton—Fire recently destroyed local electric-light plant. Loss, $4,000.

Iowa, Clermont—C. Miller & Sons plan to increase the capacity of its electric-light plant. Estimated cost, $20,000.

Iowa, Marshalltown—Bids are being received by W. S. McFarland, Supt., Water Wks., for 4,000,000-gal. pump. Estimated cost, $12,000.

Iowa, West Union—Turkey River Power Co. plans to improve its plant. Estimated cost, $20,000.

Minn., Slayton—Slayton Power Co. plans to enlarge its plant and install new equipment.

Kan., Bucklin—Citizens contemplate $10,000 bond issue for improving electric-lighting system.

Kan., Atwood—Plans being prepared for municipal-electric-light plant. Estimated cost, $15,000.

Kan., Milan—Construction of electric-light plant contemplated by Nathan L. Jones, Wellington, Kan.

Neb., Blair—Bids will be received by S. W. Chambers, City Clk., until Oct. 15, for electric-light plant. Estimated cost, $34,000.

Neb., Tekamah—A. G. Howard will soon be in the market for a 150-hp. Corliss engine, two boilers and a 100-kw. generator and switchboard.

N. D., Ryder—Construction of electric-light plant in Ryder contemplated by local business men.

Mo., Campbell—Campbell Electric Light and Power Co. is in the market for new equipment estimated to cost about $30,000.

Mo., Drexel—City will equip electric plant at Drexel. About $8,000 worth of machinery will be required.

Mo., Slater—Bids will be received by J. A. Stern, City Clk., until Oct. 20, for a 250-kw. 60-cycle, three-phase, 2,300-volt alternator with exciter, connected to 300-hp. engine.

Tex., Caliente—Local electric-light plant of T. J. Vines & Sons, recently destroyed by fire, will be rebuilt.

N. M., Mogollon—Earle C. Cleveland plans electric-power plant on Willow Creek.

Idaho, Blackfoot—F. V. Riley, C. E., Idaho Falls, submitted plan to City Council to install electric-light plant in Blackfoot.

Ariz., Tucson—Election to issue $100,000 bonds to complete municipal electric-lighting system contemplated by City Council.

Wash., Colfax—Work will soon be started on substation for Washington Water Power Co.